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HUMAN RESOURCE ALLOCATIONS IN AFRICAN AGRICULTURAL RESEARCH

Revealing More of the Story Behind the Regional Trends

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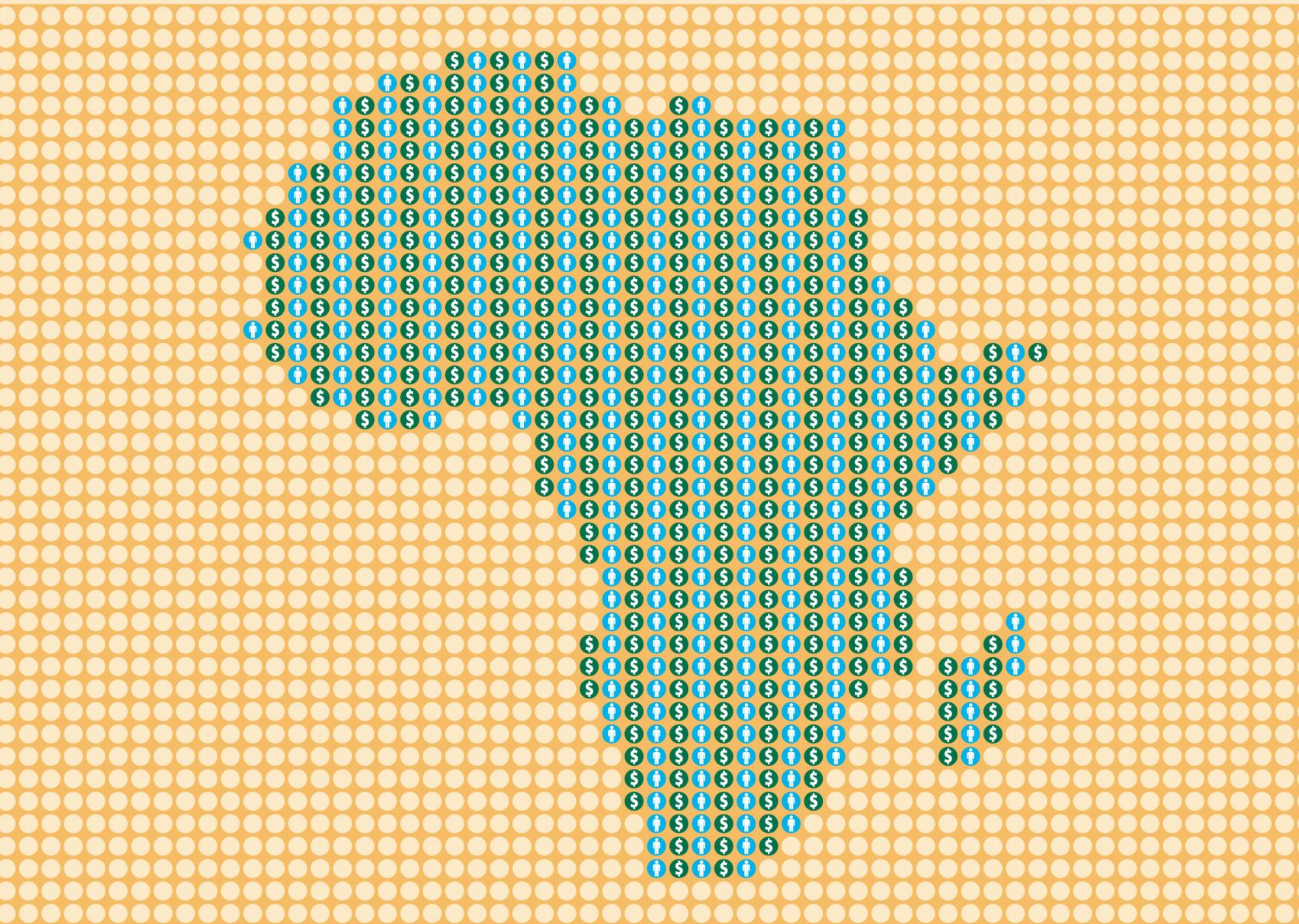
Conference Working Paper 12

Prepared for the ASTI/IFPRI–FARA Conference | Accra, Ghana | December 5–7, 2011

AGRICULTURAL R&D: INVESTING IN AFRICA'S FUTURE
Analyzing Trends, Challenges, and Opportunities



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Acknowledgments

The authors gratefully acknowledge the valuable comments of an anonymous reviewer and John Lynam for providing comments on a draft of the paper. They also thank Mary Jane Banks for editing the paper.

Acronyms

EAAPP	East Africa Agricultural Productivity Program
FTE(s)	full-time equivalent(s)
PPP	purchasing power parity
R&D	research and development
S&T	science and technology
SSA	Sub-Saharan Africa
WAAPP	West Africa Agricultural Productivity Program

Abstract

The aim of this paper is to provide an in-depth assessment of Sub-Saharan Africa's human resource capacity in agricultural research based on the wealth of detailed human capacity data collected through the Agricultural Science and Technology Indicators (ASTI) initiative. The region's overall agricultural R&D capacity has increased notably in recent years. In addition to this increase in absolute numbers, female participation improved in many countries and comparatively more researchers hold PhD and MSc degrees—although the share of those qualified to the BSc level increased for some countries during 2001–08. Nevertheless, many countries, especially some of the region's smallest, still have very low (and in a few cases declining) levels of human resource capacity. Agricultural research continues to be extremely fragmented, with most countries focusing on a large number of subsectors and wide range of crops, which remains the dominant subsector. Furthermore, after years of civil service recruitment freezes, many countries have disproportionately young and inexperienced teams of agricultural scientists in need of further training and mentoring, combined with disproportionately older senior scientists, many of whom are nearing retirement age. A further problem due to years of underfunding in many countries is the need to improve salary levels, conditions of service, facilities and equipment, and networking and career-development opportunities, which are fundamental to successfully attracting and retaining the kind of scientists needed to address the multitude of research challenges that await.

1. INTRODUCTION

Agricultural science and technology (S&T), like S&T more generally, is knowledge-intensive. Consequently, a viable national S&T effort requires not only a sustainable and sufficient level of investment, but also a stable supply of scientists and technical support staff with the right training, skills, and motivation. This is especially true in developing countries, where the goal has shifted from simply consuming developed-country technologies, to adapting those technologies and developing new, locally targeted ones. Ultimately, countries that lack appropriate S&T capacity fall behind (IAC 2004; Huyer and Westholm 2007). To this end, concern is building over the lack of human resource capacity in agricultural research and development (R&D) in Sub-Saharan Africa (SSA) calling into question the ability of many countries to respond to emerging global challenges.

This paper provides an in-depth overview of trends in human resource capacity in public agricultural R&D in SSA, based on comprehensive datasets derived from primary surveys conducted during 2009–10 by the Agricultural Science and Technology Indicators (ASTI) initiative of the International Food Policy Research Institute (IFPRI) and its network of national partners.[1] This paper provides a more detailed analysis of general human resource capacity developments described in Beintema and Stads (2011) and in ASTI's country notes. The paper assesses the allocation of the human resource base providing analyses not previously published elsewhere. The sample includes 32 countries that contribute more than 90 percent of the region's agricultural GDP.

2. GENERAL STAFFING TRENDS

In 2008, SSA employed more than 12,000 agricultural researchers, measured in full-time equivalents (FTEs) (Table 1).[2] An estimated 50,000 FTE support staff, including technicians (some of whom held university degrees), administrative staff, and other support staff (such as field workers, drivers, and guards) brought the region's agricultural R&D workforce to a total of more than 62,000 FTEs in 2008. That year, Ethiopia, Kenya, Nigeria, and Sudan each employed more than 1,000 FTE researchers, accounting for 44 percent of the region's total, whereas Ghana, South Africa, and Tanzania employed 537, 784, and 674 FTEs, respectively. Beintema and Stads (2011) describe these countries, together with Uganda, as the region's "Big Eight," because they dominate any regional assessment. In contrast, 9 of the 32 ASTI countries in the sample employed fewer than 100 FTEs each.

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[1] Note that public agricultural R&D is defined in this context to include government, higher education, and nonprofit agencies, thereby excluding private enterprises. Agricultural R&D activities undertaken by international organizations are explicitly excluded from the dataset and are reported separately (see Beintema and Stads 2012 for additional information on ASTI's methodology, definitions, and data collection procedures).

[2] ASTI bases its calculations of human resources on full-time equivalent staffing, or FTEs, which take into account the proportion of time researchers spend on R&D activities. University staff, for example, spend the bulk of their time on nonresearch-related activities, such as teaching, administration, and student supervision, which need to be excluded from research-related resource calculations. As a result, four faculty members estimated to spend 25 percent of their time on research would individually represent 0.25 FTEs and collectively be counted as 1 FTE.

Table 1. Public agricultural R&D staffing levels and yearly growth rates, 1991–2008

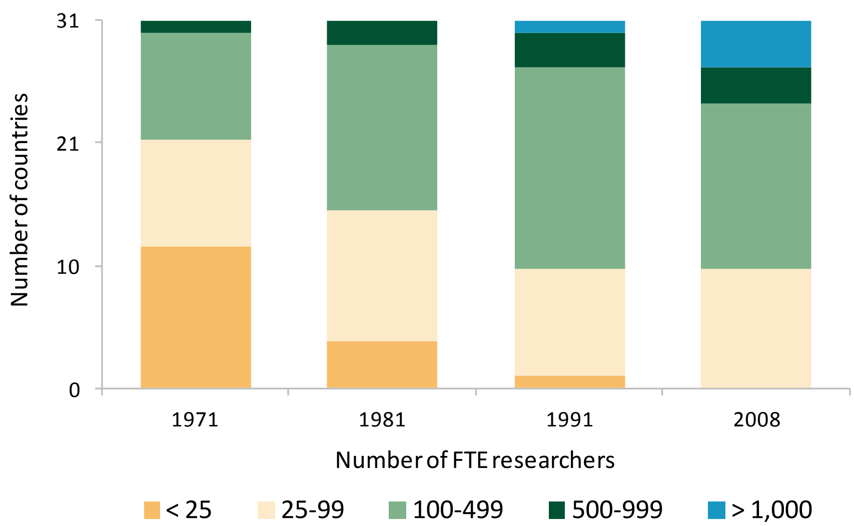
	Total number of researchers (FTE)				Yearly growth rate (%)		
Country/size in 2008	**1991–95**	**1996–2000**	**2001–05**	**2008**	**1991–96**	**1996–2001**	**2001–08**
More than 1,000 FTEs							
Nigeria	1,083	1,202	1,439	2,062	1.1	4.0	5.9
Ethiopia	425	610	1,028	1,318	8.7	10.3	6.0
Sudan	539	678	913	1,020	4.4	5.1	3.6
Kenya	970	915	925	1,011	–1.0	–1.3	1.5
500 to 1,000 FTEs							
South Africa	998	1,034	835	784	2.1	–3.2	–1.7
Tanzania	526	523	639	674	–1.1	2.8	1.4
Ghana	387	457	465	537	6.3	0.6	2.5
100 to 500 FTEs							
Mali	244	239	292	313	–0.4	–0.7	–0.7
Uganda	238	257	240	299	1.4	0.0	3.4
Mozambique	na	na	121	263	na	na	11.7
Burkina Faso	175	193	237	240	0.6	4.9	1.4
Guinea	219	235	218	229	1.6	–0.4	0.3
Madagascar	189	204	209	212	2.9	1.0	0.3
Zambia	195	196	146	209	3.2	–8.1	3.8
Mauritius	120	148	151	158	5.0	0.0	1.7
Senegal	196	166	147	141	–1.8	–4.9	0.5
Zimbabwe	na	na	154	148	na	na	–1.5
Malawi	162	165	133	127	1.7	–3.2	–1.7
Côte d'Ivoire	216	170	118	123	–4.1	–8.5	–0.1
Eritrea	na	69	90	122	na	10.7	6.6
Benin	108	114	111	115	1.0	1.9	–0.2
Rwanda	na	na	na	104	na	na	na
Fewer than 100 FTEs							
Burundi	130	61	69	98	–22.4	2.6	5.1
Botswana	44	59	76	97	8.7	6.9	5.6
Congo, Rep. of	110	124	104	94	3.1	–0.2	–2.5
Niger	101	113	100	93	3.5	–1.8	–1.9
Mauritania	na	na	66	74	na	na	3.1
Namibia	na	na	61	70	na	na	0.2
Sierra Leone	na	na	48	67	na	na	3.8
Togo	90	88	81	63	–2.4	1.6	–4.0
Gabon	26	35	41	61	7.2	4.0	8.2
Gambia, The	33	41	41	38	–0.6	3.4	–1.8
SSA total (45)	**9,001**	**9,369**	**10,404**	**12,120**	**1.2**	**1.2**	**2.8**

Sources: Compiled by authors based on country-level ASTI survey data and several secondary resources (for more information, see individual ASTI Country Notes available at www.asti.cgiar.org).
Notes: Countries are ordered from largest to smallest in terms of their total number of FTE researchers in 2008. The 45-country total excludes Djibouti and Somalia because macroeconomic data were not available. Data on capacity for the 13 non–ASTI countries were estimated. Information on ASTI's data methodology and calculation procedures is available at ASTI's website, www.asti.cgiar.org/methodology; see also Beintema and Stads 2012 (forthcoming).

Since attaining their independence, most SSA countries have made considerable progress in building their human resource capacity in agricultural R&D. In 1961, the region employed about 2,000 agricultural FTE researchers (Pardey, Roseboom, and Beintema 1995), and this number increased to

9,000 in the early 1990s, and then (as previously mentioned) to more than 12,000 in 2008. During the past four decades, most of the countries in the 32-country ASTI sample (hereafter referred to as the "ASTI countries"), excluding Eritrea, which did not become an independent country until 1993, grew substantially in terms of their total FTE researcher numbers (Figure 1). In particular, the number of mid- to large-sized systems—those employing 100–499 and more than 500 FTE researchers, respectively—increased. In 1971, 12 countries employed fewer than 25 FTE researchers, and 3 countries employed between 25 and 49 FTEs. In 2008, only 1 of the 31 countries employed fewer than 50 FTE researchers. The sample, however, excludes some of the smaller countries (in terms of national population), such as the Seychelles, Cape Verde, and Sao Tome, which likely will have very small pools of agricultural researchers. The number of countries with very sizeable teams of agricultural researchers has increased substantially. South Africa, one of the most well-established and well-funded research systems in SSA, employed 648 FTE researchers in 1971 and was the only country to employ more than 500 FTEs at that time. In 2008, this total had increased to 748 FTEs, but South Africa had been surpassed in ranking by Ethiopia (1,318 FTEs), Kenya (1,011 FTEs), Nigeria (2,062 FTEs), and Sudan (1,020 FTEs). Ghana and Tanzania also employed more than 500 FTE researchers that year.

Figure 1—Size of agricultural research capacity for 31 countries, 1971–2008



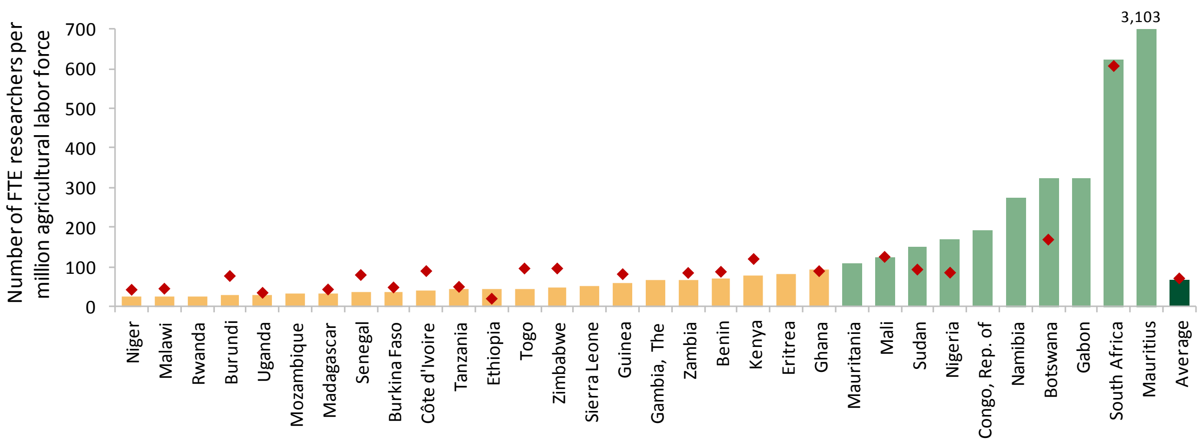
Sources: Compiled by authors based on country-level ASTI survey data and several secondary resources (for more information, see individual ASTI Country Notes available at www.asti.cgiar.org).
Notes: Data exclude Eritrea, which was gain independence until 1993. Other SSA countries excluded are mostly countries with small pools of FTE researchers (for example, Cape Verde, the Seychelles, Lesotho, and Swaziland), although a number of middle-size counties are missing as well (for example, Angola, Central African Republic, and the Republic of Congo). Were these countries included, the distribution would be different, but the long-term trend would be unlikely to differ substantially.

A closer look at the relative shifts in capacity levels over time reveals some interesting cross-country differences and challenges. Unsurprisingly, the countries with the largest absolute capacity are the main drivers of the recent growth in the region's total number of researchers. Nigeria accounted for 724 of the region's 2,285 FTE increase in researchers during 2001–08. Ethiopia, Kenya, and Sudan also reported significant increases. South Africa, however, recorded the largest decline in public agricultural researcher numbers (140 FTEs) for the eight-year period.

Changes in the capacity levels in the remaining ASTI countries during 2001–08 were less severe in absolute terms; however, a number of francophone countries in West and Central Africa reported declining capacity during this period, often associated with declining investment levels (Beintema and Stads 2011). Togo, the Republic of Congo, Gabon, and Niger recorded yearly declines of –1.8 percent or more, which is especially worrisome because capacity in these countries was already insufficient. Even more challenging is the high rate of turnover of researchers in many countries. Large shares of well-qualified and experienced researchers continue their exodus in favor of more lucrative research and nonresearch positions within and outside the region. This often occurs in tandem with the loss of researchers to retirement, which will be an ongoing problem in the coming years (Sène et al. 2012). Interestingly, despite strong contractions in spending levels in Eritrea and Ethiopia throughout this period (Beintema and Stads 2011), researcher numbers increased by 7 and 6 percent per year, respectively.

Absolute levels of human resource capacity across countries offer limited insights. Comparative measures, such as the intensity of agricultural research, can be more revealing. The number of researchers as a share of the agricultural labor force is one such indicator (Figure 2). Although the region's total number of publicly employed FTE researchers in agricultural R&D grew by about 40 percent during 1991–2008, the total agricultural labor force increased slightly more, lowering the average number of researchers per million economically active agricultural population from 70 in 1991 to 68 in 2008. Again, wide variation occurred across countries. Botswana, Gabon, Mauritius, Namibia, and South Africa employed more than 200 FTE researchers per million economically active agricultural population.

2. Full-time equivalent researchers per million farmers, 2008 compared with 1981



Sources: Compiled by authors based on country-level ASTI survey data and economically active agricultural population data (here labeled as agricultural labor force) from FAO (2011).
Notes: The bars depict the intensity ratio for 2008, the red dots those for 1981; 1981 intensity ratios were missing for Republic of Congo, Eritrea, Gabon, the Gambia, Mauritania, Mozambique, Namibia, and Sierra Leone due to a lack data for that year.

The Increasing Role of the Higher Education Sector

Agricultural research is undertaken by a handful of government agencies and university faculties in most of the smaller SSA countries (Flaherty 2011); systems in the Big Eight countries like Kenya, Ghana, Nigeria, South Africa, and Sudan are, understandably, far more complex. Overall, the government sector still dominates agricultural research in the region (Figure 3), but its relative share has declined over time. In 1991, government agencies employed 82 percent of public FTE agricultural researchers in SSA, but this share had fallen to 73 percent in 2008, as a result of the growing presence of the higher education sector (Beintema and Stads 2011). During 1991–2008, the corresponding shares of total FTE researchers in the higher education sector grew from 15 to 24 percent.[3] In absolute terms, however, the total number of FTE researchers in the higher education sector more than doubled during 1991–2008, mainly

[3] The nonprofit and private-sector shares of total agricultural R&D capacity remained very small (Beintema and Stads 2011; Pray, Gisselquist, and Nagarajan 2011).

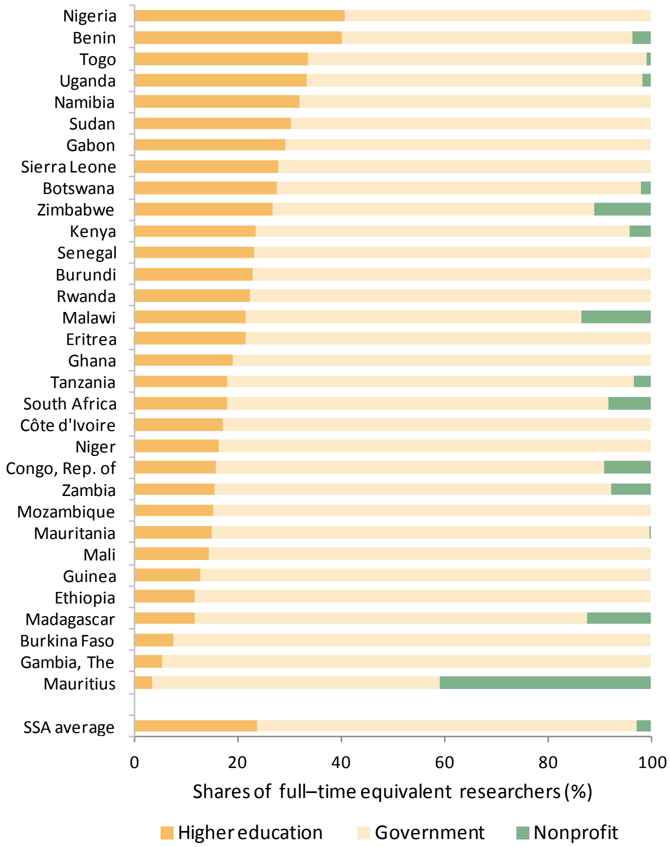
as a result of the establishment of new higher education units involved in agricultural research. Most of these new agencies were established in Nigeria and Sudan, where the higher education sector accounted for 41 and 30 percent of total public FTE researchers in 2008, respectively, representing a substantial increase from the corresponding 1991 shares of 30 and 21 percent, respectively (Beintema and Stads 2011).

Flaherty et al. (2010) identified close to 90 higher education agencies with agriculture-related programs in Nigeria, including specialized universities, agricultural faculties, and smaller units. The faculties of agriculture and veterinary medicine at the country's four oldest universities—Ahmadu Bello University, the University of Ibadan, the University of Nigeria, and Obafemi Awolowo University—continued to dominate the higher education sector's contribution to agricultural research. Nevertheless, their combined share in agricultural research capacity declined slightly due to the introduction of new higher education agencies, which attracted staff away from the established universities. Many of the newer universities are private or state-based and primarily focus on BSc-level training, so they conduct limited research.

Stads and El-Siddig (2010) identified 31 higher education agencies conducting agricultural R&D in Sudan. Combined, the number of agricultural researchers employed by these agencies more than doubled from 1991 to 2008, and their share of overall capacity increased from 21 to 30 percent. The faculties of agriculture, animal production, and veterinary medicine of the University of Khartoum and the University of Gezira accounted for 45 percent of Sudan's total research capacity in the higher education agencies in 2008. Many of the remaining higher education agencies were only established in the 1990s in response to the national government's 1995 subdivision of the country into 26 rather than 9 states. The overall quality of agricultural research conducted at these relative newer faculties is generally poor, based on underfunding and a total lack of research management structures. Despite the high and increasing number of higher education agencies conducting agricultural research in Nigeria and Sudan, the individual capacity of most of them in terms of FTE researcher numbers, excluding the aforementioned older universities, remains small.

In Uganda, agricultural R&D capacity in the higher education sector also increased significantly, from 12 FTEs in 1981, to 75 FTEs in 2001, to 99 FTEs in 2008. The sector now accounts for one-third of the country's public agricultural research capacity (Flaherty, Kitone, and Beintema 2010). Uganda's main university, Makerere University—which is largely responsible for this growth—operates four faculties and an institute involved in agricultural research. The growth of Makerere University's R&D activities can be partly attributed to the revised agricultural R&D legislation in 2005, which aimed to improve the delivery of Uganda's agricultural R&D services through closer cooperation between public and private research agencies, stakeholders, and policymakers. Makerere University officially became a private research body, which allowed the university to pursue external funding sources and compete for research funding from government sources. In 2008, Makerere University initiated a new policy to strengthen research capacity and output, and increase the university's contribution to Uganda's knowledge and innovation generation (Okori 2011).

Figure 3—Institutional composition across countries, 2008

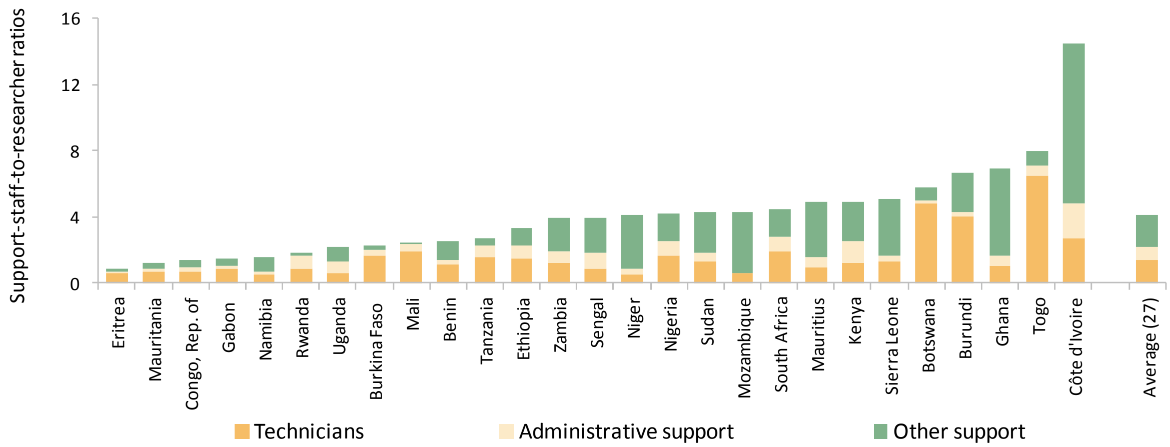


Sources: Compiled by authors based on country-level ASTI survey data and several secondary resources (for more information, see individual ASTI Country Notes available at www.asti.cgiar.org).

Levels of Support Staff

In 2008, the more than 12,000 FTE researchers and 40,000 FTE support staff, as previously discussed, resulted in an average ratio of support staff to researchers of about 4 to 1 FTEs, comprising 1.4 technicians, 0.8 administrative staff, and 1.9 other support staff (Figure 4). This ratio varied widely, from fewer than 2 FTE support staff per researcher in Eritrea, the Republic of Congo, Mauritania, Namibia, and Rwanda, to between 5 and 8 FTE support staff per researcher in Botswana, Burundi, Ghana, Sierra Leone, and Togo. At 14.3 to 1, the ratio was particularly high in Côte d'Ivoire because large numbers of other support staff were employed in cocoa and coffee production schemes at the country's main agricultural research agency (Stads and Doumbia 2010). Wide variation in the type of support is also prevalent across countries; for example, Botswana, Mali, and Togo employ higher share of technicians, whereas Mauritius, Mozambique, Niger, and Senegal all employ comparatively fewer technicians and more unskilled labor for field work.

Figure 4—Ratio of support staff per researcher, 2008



Sources: Compiled by authors based on country-level ASTI survey data and several secondary resources (for more information, see individual ASTI Country Notes available at www.asti.cgiar.org).
Note: The figure excludes The Gambia, Guinea, Madagascar, Malawi, and Zimbabwe due to lack of available data.

There is no uniform recommendation on the "ideal ratio" of support staff to researchers. Many countries, however, have lowered their ratios in recent years in efforts to improve agricultural research efficiency. From the early 1990s, the need to rationalize the support staff ratio was further motivated by funding shortages, in turn prompting recruitment freezes, voluntary staff departures, and early retirement schemes in many African countries. The "other support staff" category was the most affected by these cuts (Beintema and Stads 2006), although the ratios of technical and administrative support also declined markedly in some countries. More recent data show that these support-staff cuts continued into the 2000s, but seemingly not to the same degree as in the 1990s.

4. QUALIFICATION LEVELS OF RESEARCHERS

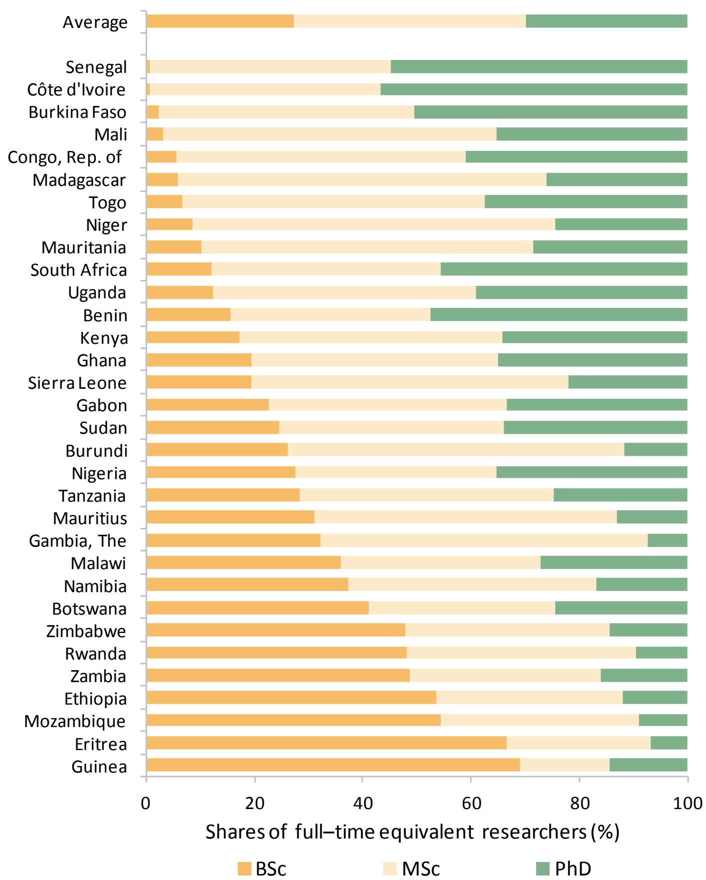
Of the agricultural researchers employed in the ASTI countries in 2008, 30 percent were qualified to the PhD level, 43 percent to the MSc level, and 27 percent to the BSc level.[4] Researcher qualifications varied considerably across countries (Figure 5). In just 14 of the 32 ASTI countries, more than 80 percent of FTE researchers were trained to the postgraduate (PhD or MSc) level. More than half the FTE researchers employed in Burkina Faso, Côte d'Ivoire, and Senegal, and more than 40 percent of those employed in Benin, the Republic of Congo, and South Africa, were trained to the PhD level. It is striking that many West African countries have maintained relatively large pools of well-qualified agricultural researchers despite recent losses in human and financial resource capacity. These high shares stem in large part from training programs conducted during the 1990s (and earlier), funded through bilateral donors or World Bank–financed projects.

With two-thirds or more of the agricultural research staff qualified to the BSc level only, researchers in Eritrea and Guinea are the least highly qualified of those in the 32 sample countries. BSc-qualified researchers accounted for 54 percent of agricultural FTEs in Ethiopia and Mozambique, which is also very high. The overall limited research capacity in small countries, alongside low numbers of well-qualified staff and limited training opportunities, poses significant constraints on the ability of these countries to conduct high-quality research and to attract external funding. As an example, The Gambia employed only 38 FTE agricultural researchers in 2008, and only two were trained to the PhD level (Stads and Manneh 2010).

[4] This section is taken from Beintema and Stads (2011), with some minor revisions.

South Africa's universities predate those of the rest of the region, which explains the consistently high number of well-trained agricultural research staff in that country. Moreover, a high and growing number of students from other SSA countries are attending South African universities, increasing the importance of their role in training future generations of African agricultural R&D staff. The downside of this, however, is that many students remain in South Africa to take advantage of the career opportunities available, which contributes to the issue of "brain drain" from other countries.

Figure 5—Distribution of agricultural researchers by country and degree qualification, 2008



Sources: Compiled by authors based on country-level ASTI survey data and several secondary resources (for more information, see individual ASTI Country Notes available at www.asti.cgiar.org).
Note: Data exclude technicians and support staff with university degrees that are not officially classified as researchers.

Despite growth in agricultural R&D capacity across the region, average levels of staff qualifications actually deteriorated somewhat during 2001–08 for a combined sample of 30 ASTI countries (excluding Rwanda and Mozambique). In 2008, 27 percent of all FTE researchers held BSc degrees, up from 24 percent in 2001. The overall share of PhD-qualified researchers rose only slightly during this period, from 29 to 30 percent, but trends were more pronounced in certain countries. In 2008, half of Zambia's public agricultural researchers were trained to the MSc and PhD levels—a significant shift from 2001, when 70 percent of researchers held postgraduate degrees. The increasing share of BSc-qualified staff in Zambia stems from a government-sector hiring freeze, lack of appropriate training opportunities, and the concurrent reduction in the number of senior researchers due mainly to retirement and departures to other agencies (Flaherty and Mwala 2010). In Nigeria, the overall share of PhD- and MSc-qualified researchers fell from 79 to 72 percent during 2001–08, and in Botswana this share fell from 66 to 59 percent. In Ethiopia, Ghana, and Uganda postgraduate shares declined by 3 to 4 percentage points during this timeframe. Higher shares of BSc-qualified researchers were often the result of recruitment bans being lifted, lack of training opportunities, and declining numbers of senior staff. Most of these countries with relatively high shares of researchers qualified to the BSc level only are limited in their ability to compete for funding and collaborate with other agencies at regional levels.

In 2008 PhD-qualified staff constituted higher shares in the higher education sector than in the government or nonprofit sectors—52 percent compared with 24 and 29 percent, respectively—but this is common in SSA countries and others around the world. The deterioration in average qualification levels was more pronounced at the government agencies, where the share of BSc-qualified researchers increased from 27 to 31 percent during 2001–08 compared with 11 to 13 percent at the higher education agencies.

An increasing number of support staff (technicians, research assistants, and laboratory assistants) have BSc, MSc, and occasionally PhD qualifications, but they are not officially classified as researchers. In Senegal, for example, the minimum requirement for a researcher is an MSc degree, so the 105 scientists employed at ISRA with BSc qualifications are classified as technicians (Stads and Sène 2010). Half of the technicians and other research support staff at NARO in Uganda held MSc or BSc degrees. Although the number of research positions at NARO has increased in recent years, promotional opportunities remain limited because applicants must meet specific minimum requirements, one of which is an MSc degree (Flaherty, Kitone, and Beintema 2010). Unlike the situations in Senegal and Uganda, support staff at Tanzania's DRD are promoted to researcher status upon obtaining their BSc degrees (Flaherty and Lwezaura 2010). The pool of degree-qualified support staff is sizeable in some countries. In Senegal, 43 percent of all degree-qualified research staff are technicians, and in Mauritius, Nigeria (government agencies only), and Uganda this share is about 25 percent. It is important to capture quantitative information on research technicians, who—given proper training and promotional opportunities—will be a valuable resource in the future development of African agricultural R&D.

A major concern in many countries is a rapidly aging pool of scientists, many of whom will approach retirement within the next decade. A further complicating factor is that many government agencies with uncompetitive salaries; conditions of service; infrastructure; and training, networking, and promotional opportunities, often due to funding constraints, are severely challenged in their ability to retain well-qualified staff based on attractive opportunities in the higher education or private sectors, or abroad (Beintema and Stads 2011; Sène et al. 2012). Attracting and retaining staff is an even more serious problem in countries with small research capacities (Flaherty 2011).[5]

5. FEMALE PARTICIPATION IN AGRICULTURAL RESEARCH

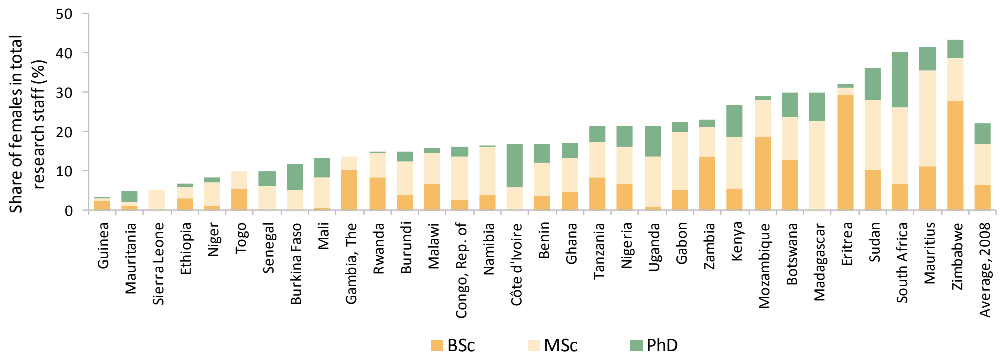
Greater representation of women in agricultural research is urgently needed at the researcher level, but even more so at the managerial level.[6] Women in agricultural research, as in any sector, contribute a wide diversity of new insights and perspectives, particularly when it comes to addressing the unique and pressing challenges of both male and female farmers (IAC 2004; Huyer and Westholm 2007; Meinzen-Dick et al. 2011). Female farmers are significant contributors to agricultural production in Africa, yet agricultural research, including extension and higher education, is disproportionately framed, managed, and conducted by men. Moreover, women are a valuable resource that could be tapped to address the capacity constraints in agricultural R&D in many countries, both short and long term.

[5] This lack of a critical mass of well-qualified researchers in small countries also highlights the need for regional initiatives focusing on the needs and vulnerabilities of such countries.

[6] This section is a summary of Beintema (2012, forthcoming).

Based on a sample of 32 countries in 2008, 22 percent of FTE researchers employed in agriculture were female (Figure 6).[7] The share of women qualified to the BSc level was higher than the share of women qualified to either the MSc or PhD levels (26 percent compared with 23 and 17 percent, respectively). Shares of female agricultural researchers differed substantially across countries, however. In general, South African countries employ higher shares of female researchers compared with countries in West and Central Africa. In 2008, women represented at least 30 percent of all agricultural research staff in Eritrea, Madagascar, Mauritius, South Africa, Sudan, and Zimbabwe. In contrast, of the agricultural researchers employed in Ethiopia, Guinea, Mauritius, Niger and Sierra Leone in 2008, only 3 to 8 percent were female. Given that significant proportions of agricultural researchers in Eritrea and Zimbabwe are only qualified to the BSc level (two-thirds and half, respectively) most female scientists in these two countries were also only trained to the level of BSc, despite a high share of women overall.

Figure 6—Shares of female researchers by country and degree level, 2008

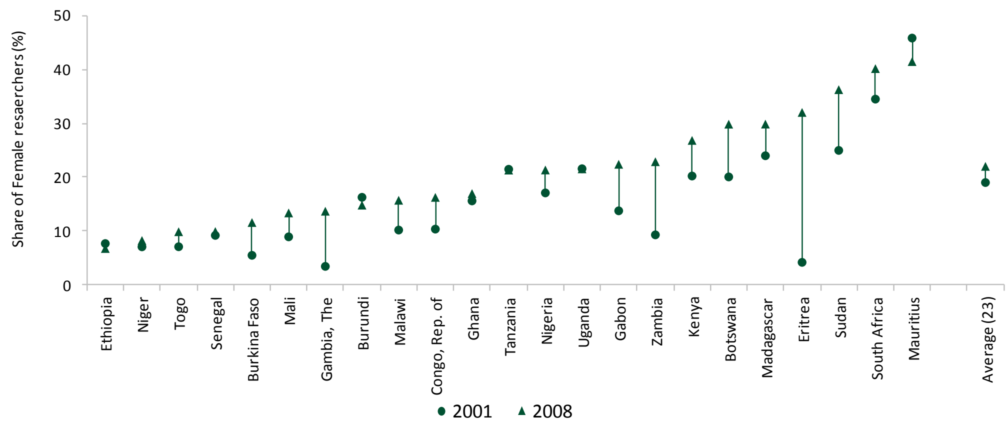


Sources: Compiled by authors based on country-level ASTI survey data and several secondary resources (for more information, see individual ASTI Country Notes available at www.asti.cgiar.org).

In a sample of 23 countries for which 2000 and 2008 gender data were available, the share of female researchers increased from 18 to 22 percent; however, the increase varied across the 23 countries (Figure 7). The contribution of women continued to increase in countries with relatively high existing shares of female researchers, but in countries where women were already significantly underrepresented, shares grew little. Accordingly, Sudan and South Africa's shares increased from 24 and 34 percent, to 36 and 40 percent, respectively, whereas in Ethiopia, Niger, Senegal, and Togo, existing low shares of female researchers grew very little.

[7] Gender-disaggregated data on participation in overall R&D, both over time and across countries, are extremely important for national and international decisionmakers, including research and human resources managers. Such data remain scarce, however, in the developing world. ASTI is one of the few resources of gender-disaggregated data. In many countries, decisionmakers tend to assign a low priority to gender policies, so there is little demand for gender-disaggregated data; this in turn creates a lack of awareness of gender gap in R&D (Huyer and Westholm 2007; Beintema 2012).

Figure 7—Growth in shares of female researchers for 23 African countries, 2001 and 2008



Sources: Compiled by authors based on country-level ASTI survey data and several secondary resources (for more information, see individual ASTI Country Notes available at www.asti.cgiar.org).

The growing shares of professional women employed in agriculture and female students enrolled in agricultural sciences indicate that the gender gap in African agricultural sciences may be narrowing, especially in Southern Africa. Nevertheless, the vast majority of the increase in the number of both men and women in African agricultural research and higher education mostly comprises young and inexperienced scientists qualified to the BSc level only. On average, more than half the female professional staff in a 15-country sample were younger than 41 years old compared with 42 percent of the total male professional staff, and 31 percent of female staff and 27 percent of male staff were qualified to the BSc degree level only (Beintema and Di Marcantonio 2010).

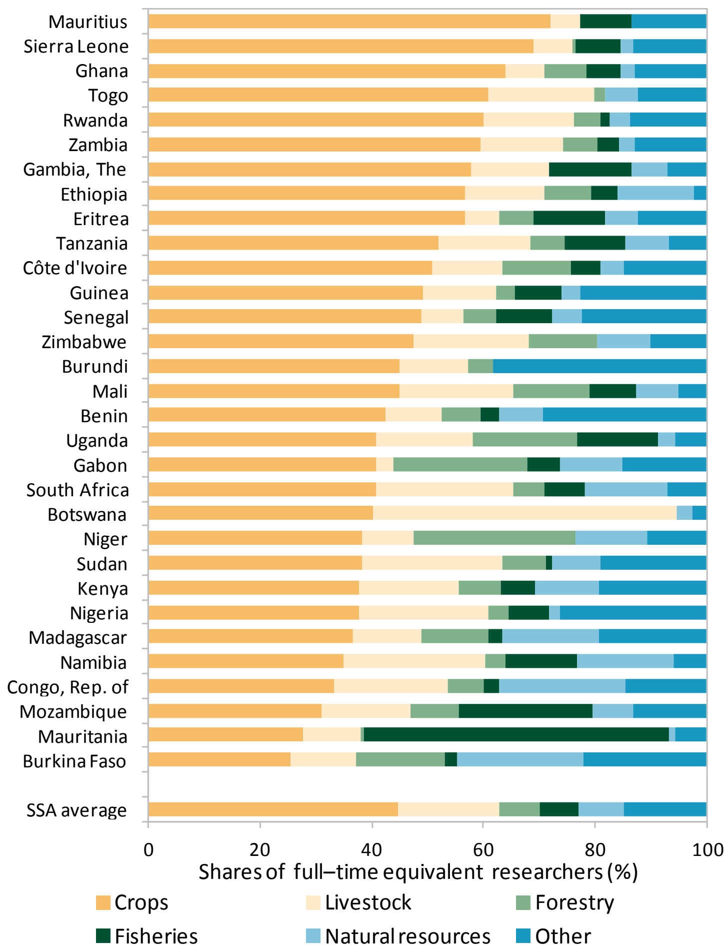
The total number of female FTE researchers increased by 5 percent per year from 2001 to 2008—more than twice the yearly rate of 2 percent for the male researcher population. In absolute terms, the total number of male FTE researchers in agriculture increased faster than the total number of female researchers during this period (1,040 men versus 668 women). The number of female researchers qualified to the MSc-degree level increased by 275 compared to only 46 for male researchers. The number of MSc-qualified male researchers actually declined in a number of countries, between 2001 and 2008, but this was actually because a high number of male MSc-qualified researchers attained PhD degrees or left their organizations to accept other positions.

In many countries, institutional reforms and policies have been initiated to promote gender equality, but women continue to be underrepresented in high-level research and management positions, and as a result have less influence in policy- and decisionmaking processes. Various actions must be taken to reduce the gender gap across all scientific fields, but especially in agriculture. This will involve changes in the stereotypical view of science as largely a male domain. It will also involve shifting cultural and familial values that serve to deter female participation in agricultural research. More girls will need to stay in school and be encouraged to pursue scientific careers, but this can only achieved through continuous awareness campaigns. At the institutional level, access to role models and mentors, and the provision of networks and support systems have proven to be powerful tools for inspiring (young) women into scientific fields. Finally, eliminating or at least lessening the gap in the pay scale between men and women would contribute to attracting more women into the agricultural sciences, as well as sciences more generally (Meinzen-Dick et al. 2011; Andres 2011; Beintema 2012).

6. THE ALLOCATION OF RESEARCH BY FOCUS

The allocation of resources among various lines of research is a significant policy decision, so detailed information was collected on the allocation of FTE researchers across specific commodity areas. In 2008, 45 percent of the FTE researchers in a 30-country sample (excluding Malawi and Zimbabwe) conducted crop research, whereas 20 percent undertook livestock research (Figure 8). Natural resources research accounted for 8 percent, while fisheries and forestry accounted for 7 percent each. The allocation of FTE researchers by major subsector are similar to the ratios recorded in 2000/01 (Beintema and Stads 2006). The remaining 15 percent of the researchers focused on other areas, including socioeconomics and areas relating to onfarm postharvest practices.

Figure 8. Researchers by major subsector, 2008



Sources: Compiled by authors based on country-level ASTI survey data and several secondary resources (for more information, see individual ASTI Country Notes available at www.asti.cgiar.org).

Unsurprisingly, large differences were observed in the focus of agricultural research across countries. Crop research was the focus of 60 percent or more of the researchers in Ghana, Mauritius, Rwanda, Sierra Leone, and Togo in 2008. In contrast, Botswana and Mauritania are unique to both Sub-Saharan Africa and developing countries more generally: more researchers in Botswana focus on livestock than on crop research (54 percent compared with 40 percent in 2008), and in Mauritania significantly more researchers focus on fisheries research than on crop research (55 percent compared with 28 percent in 2008). Burkina Faso, Gabon, Madagascar, Mozambique, and Niger have more diverse agricultural research systems, with the result that crop and livestock research accounted for less than half of all FTEs. For most other countries, crop and livestock remained the dominant focus, with combined shares of two-thirds to three-quarters, respectively.

The focus of crop research in many SSA countries is highly diverse; the major crops under research in Africa are maize and fruit, each accounting for 9 percent of all crop researchers in 2008 (Table 2). Other important crops include rice, vegetables, wheat, sorghum, and cassava, 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. The country-level focus of crop research is different, however. Rice and cassava are important crops under research in most West and Central African countries and in a handful of countries in other parts of the continent. Rice is the most highly researched crop in Madagascar, whereas in Mozambique the dominant crop under research is cassava. Wheat and maize research are important in East and Southern African countries, although many West African countries also conduct substantial research on maize. Crop researchers in a number of countries focus substantial time on other crops, such as groundnuts in Botswana, Gambia, Mozambique and Niger; cotton in Benin, Mali, and Togo; coffee in Burundi and Uganda; tobacco in Zimbabwe; cocoa in Ghana; and sugarcane in Mauritius.

Table 2—Major crops by country, 2008

Country	Major crop items
Benin	Cassava (18%), cotton (14%) oil palm (11%), yam (11%), rice (10%), bananas (9%), vegetables (7%)
Botswana	Sorghum (37%), vegetables (14%), fruits (14%), groundnuts (14%), maize (7%), wheat (7%), millet (7%)
Burkina Faso	Rice (26%), sorghum (26%), maize (19%), millet (10%), vegetables (10%)
Burundi	Coffee (14%), vegetables (13%), fruit (11%), rice (9%), potatoes (7%), maize (5%)
Congo, Rep. of	Cassava (31%), vegetables (14%), yam (8%), bananas and plantains (7%), maize (7%), groundnuts (5%), other fruits (5%)
Côte d'Ivoire	Rice (9%), vegetables (8%), cotton (8%), cocoa (8%), oil palm (7%), bananas (5%)
Eritrea	Sorghum (36%), wheat (14%), millet (8%), barley (8%), vegetables (8%), maize (7%), potatoes (6%)
Ethiopia	Wheat (18%), maize (10%), sorghum (7%), barley (7%), vegetables (7%), potatoes (6%), coffee (5%)
Gabon	Bananas (36%), sugarcane (5%), oil palm (5%)
Gambia, The	Groundnuts (24%), millet (17%), rice (14%), maize (8%), fruits (8%), cassava (7%)
Ghana	Cocoa (11%), cassava (11%), maize (10%), rice (9%), vegetables (7%), oil palm (5%), potatoes (5%), yam (5%)
Guinea	Sorghum (26%), potatoes (13%), coffee (8%), oil palm (8%), maize (7%), ornamentals (6%)
Kenya	Maize (18%), coffee (10%), vegetables (8%), potatoes (8%), wheat (8%), other fruit (7%), bananas (6%), sorghum (5%)
Madagascar	Rice (33%), fruit (12%), coffee (9%), maize (8%), vegetables (8%), ornamentals (5%)
Mali	Rice (31%), cotton (17%), vegetables (11%), millet (10%), potatoes (8%), sorghum (7%), fruits (5%)
Mauritania	Rice (33%), vegetables (22%), fruits (15%), sorghum (13%)
Mauritius	Sugarcane (48%), vegetables (17%), fruits (12%)
Mozambique	Cassava (18%), maize (14%), groundnuts (13%), rice (11%), soybeans (10%), cotton (7%)
Namibia	Millet (33%), sorghum (13%), potatoes (13%)
Niger	Groundnuts (26%), millet (15%), sorghum (13%)
Nigeria	Cassava (10%), maize (6%), oil palm (6%)
Rwanda	Potatoes (12%), maize (11%), other fruits (10%), bananas (9%), rice (9%), vegetables (7%), coffee (7%), wheat (7%), cassava (6%), millet (6%), sorghum (5%)
Senegal	Rice (20%), millet (14%), vegetables (10%), maize (9%), bananas (8%), cassava (7%), sorghum (7%), groundnuts (7%)
Sierra Leone	Rice (30%), cassava (29%), sorghum (8%)
South Africa	Fruits (36%), maize (19%), wheat (13%), potatoes (6%)
Sudan	Sorghum (12%), vegetables (11%), cotton (11%), wheat (11%), fruit (8%), groundnuts (5%), millet (5%)
Tanzania	Maize (12%), rice (6%), cassava (6%)
Togo	Maize (18%), cotton (14%), rice (14%), sorghum (12%), yam (9%), cassava (9%), cocoa (7%), coffee (6%)
Uganda	Coffee (21%), bananas (20%), cassava (7%), oil palm (6%)
Zambia	Maize (19%), sorghum (13%), fruits (11%), cassava (10%), vegetables (9%), groundnuts (5%), soybean (5%)
Average (30)	**Maize (9%), fruits (9%), rice (7%), vegetables (7%), wheat (7%), sorghum (6%), cassava (5%)**

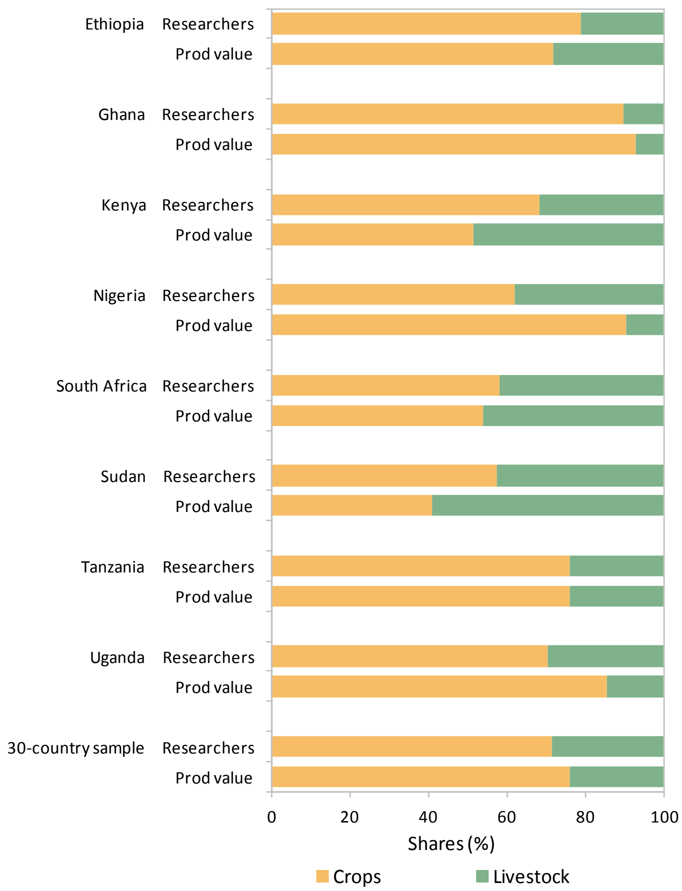
Source: Compiled by authors based on country-level ASTI survey data.
Notes: Major crop items are defined as those on which at least 5 percent of a country's crop researchers focused. Fruits include bananas, except for countries where bananas alone accounted for 5 percent or more of the country's crop research. Malawi and Zimbabwe were excluded due to lack of available data.

Comparing the allocation of funds or researchers across major agricultural subsectors or key crops with their corresponding contribution to the value of agricultural production can be a more useful assessment method.[8] However, information on the allocation of FTE researchers across major subsectors of agriculture and crops is limited. Further trends are revealed by comparing the shares of major subsectors of agriculture and crops in terms of their agricultural production value with shares of FTE researchers. Unfortunately, the availability of annual agricultural production statistics for different crops, livestock items, and subsectors for many African countries is limited. The total value of crop and livestock production by country, however, could be calculated using annual production data and international producer prices for crop and livestock items available through the FAO (2011).[9] In 2008, for the combined sample of 30 SSA countries, 72 percent of all FTE crop and livestock researchers focused on crops on average, whereas crops contributed a 76-percent share of the total production value of the two subsectors combined that year (Figure 9). Considering the Big-Eight countries only, there was considerable disparity in the share of Nigerian researchers focusing on livestock (38 percent) compared with the subsector's share of total production value (only 10 percent). This indicates a potential inefficiency in the system. The situation was similar in Uganda, although the disparity in the shares was slightly less. In contrast, in Ethiopia, Kenya, and Sudan, the share of researchers focusing on livestock research was less than the share of livestock in production value.

[8] The practice of allocating funds among research areas in proportion to their corresponding contribution to the value of agricultural production is called the congruency or parity model. For example, if the value of rice output were twice that of maize, then congruence would be achieved if research on rice were to receive twice as much funding (or, say, employ twice as many scientists) as research on maize. The parity model assumes that an additional dollar spent on research would yield a higher return if spent in areas with a relatively low ratio of research funding to output value (Alston, Norton, and Pardey 1998).

[9] FAOSTAT data on crop and livestock production by metric ton were multiplied by international producer prices (in U.S. purchase power parity [PPP] dollars) to calculate total production values for crop and livestock items, which were then aggregated to reflect the crop and livestock subsectors. These data were estimated by FAO and are averages for 1999–2001 (FAO 2011). Producer prices, however, were available for crop and livestock items but not for forestry, fisheries, or other agricultural subsectors.

Figure 9—Shares of crop and livestock research compared with their production values, SSA's "Big Eight," 2008



Sources: Compiled by authors based on country-level ASTI survey data and FAO (2011).

A similar comparison can be made by applying the same method to specific crops. Table 3 presents results for SSA's major crops: cassava, maize, rice, sorghum, wheat, fruit, and vegetables, in countries that allocate at least 5 percent of their FTE researchers to those crops.[10]

[10] A number of crop items are important in terms of their share of production value—such as yams, which accounted for an impressive 14 percent of the total value of crop production—but are excluded from the analysis in this paper because they attract only a limited number of FTE crop researchers (less than 2 percent of all crop researchers in the 30 SSA countries).

Table 3—Full-time equivalent researchers and values of production as shares of major crop and country totals, 2008

Major crop/country	Country share of 30-country total		Crop share of country's crop total	
	FTE researchers (%)	Production value (%)	FTE researchers (%)	Production value (%)
Cassava				
Nigeria	30.5	50.2	9.9	12.3
Ghana	13.3	12.8	10.6	17.0
Tanzania	8.8	6.1	6.3	9.6
Mozambique	5.8	6.1	18.0	25.8
Sierra Leone	5.4	0.4	29.4	6.7
Crop total (30 countries)	—	—	*5.5*	*8.2*
Sample total (30 countries)	*63.8*	*75.6*	—	—
Maize				
Ethiopia	17.8	9.1	10.0	9.3
Kenya	14.5	5.7	17.7	11.2
South Africa	11.4	30.5	18.6	26.6
Nigeria	10.6	18.0	5.9	3.4
Tanzania	9.9	8.5	12.2	10.5
Ghana	7.3	3.5	9.9	3.7
Zambia	5.5	3.5	9.9	3.7
Crop total (30 countries)	—	—	*9.4*	*6.4*
Sample total (30 countries)	*77.0*	*78.8*	—	—
Rice				
Mali	14.6	10.3	31.1	19.5
Guinea	9.3	9.7	26.1	22.9
Ghana	9.3	1.9	9.2	1.3
Ethiopia	8.4	0.2	3.4	0.1
Nigeria	8.1	26.5	3.3	3.4
Madagascar	7.4	24.8	33.4	45.1
Tanzania	6.9	8.5	6.1	7.0
Crop total (30 countries)	—	—	*6.8*	*4.3*
Sample total (30 countries)	*64.0*	*81.9*	—	—
Sorghum				
Ethiopia	20.4	10.0	6.8	5.7
Sudan	13.8	16.8	12.2	17.2
Eritrea	9.2	0.3	35.5	18.6
Kenya	6.5	0.2	4.8	0.3
Zambia	6.3	0.0	13.2	0.2
Burkina Faso	5.9	8.1	25.6	11.0
Botswana	5.6	0.1	37.1	7.8
Tanzania	5.6	3.7	4.1	2.6
Crop total (30 countries)	—	—	*5.6*	*3.6*
Sample total (30 countries)			—	—
Wheat				
Ethiopia	47.1	41.9	18.2	8.1
South Africa	12.0	36.6	13.5	6.0
Sudan	10.3	10.0	10.6	3.5
Kenya	9.2	4.9	7.7	1.8
Crop total (30 countries)	—	—	*6.5*	*1.2*
Sample total (30 countries)	*78.6*	*93.4*	—	—

Sources: Compiled by authors based on country-level ASTI survey data and FAO (2011).
Notes: Major crop items are defined as those on which at least 5 percent of a country's crop researchers focused. The data excludes yams, which was an important crop in terms of value of crop production (14 percent) but was the subject of limited research (1.6 percent) by the 30 SSA countries combined.

Cassava. Nigeria is the region's largest country, accounting for 31 percent of 30 ASTI countries' cassava researchers (in FTEs) and half the total value of their combined cassava production in 2008. It was also the Nigeria's main crop in terms of total crop research and production value (see also Table 2). In four of the five major countries, cassava's share of total crop production value was higher than its corresponding share of total crop researchers. The exception is Sierra Leone, where cassava's share of research was four-times larger than its share of production value.

Maize. Although maize is not a very important crop in terms of its share of total crop production value in Kenya, the country accounted for 15 percent of the region's total maize researchers, and maize research was one of the main crops being researched, accounting for 18 percent of all crop research. In contrast, South Africa accounted for close to one-third of all maize production value in 2008, and 11 percent of maize researchers were from South Africa. Maize was an important crop in terms of research, accounting for 19 percent of the country's crop researchers.

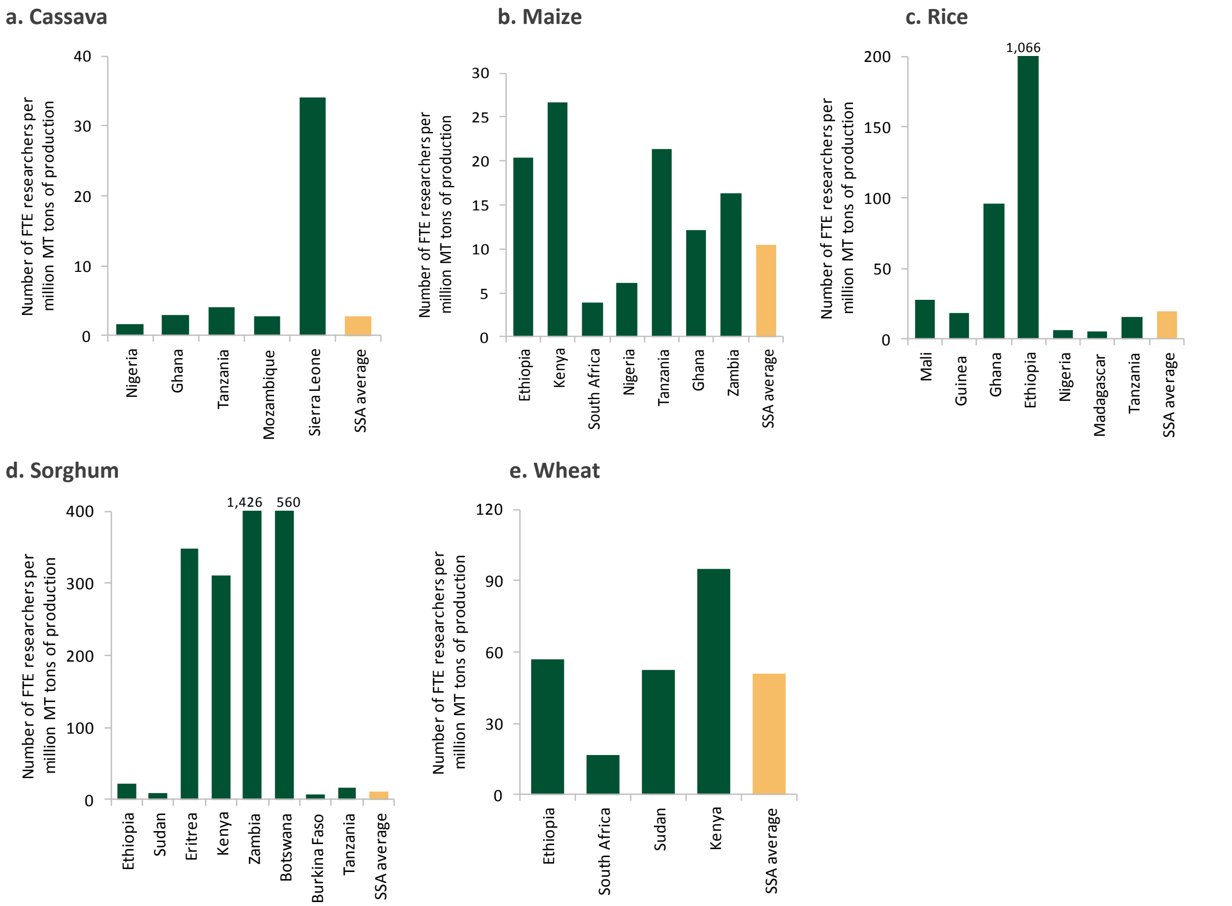
Rice. Rice is an important crop in terms of both value of production and researchers in West Africa. This is also the case for non–West African countries, such as Ethiopia, Madagascar, and Tanzania, where rice plays an important role in terms of research and production value. Notably, in Ethiopia rice is an important crop in terms of research (8 percent), but its value in crop production is a miniscule 0.2 percent. Rice has only recently been introduced to Ethiopia and is seen as having vast potential, which likely explains its the relatively high levels of investment in Ethiopia compared with its current contribution to the value of crop production.

Sorghum. Ethiopia and Sudan are important countries in terms of both their numbers of sorghum researchers, as well as their shares of total production value. But within each country, sorghum research and production is not very high. This contrasts with Burkina Faso, Botswana, and Eritrea, where sorghum was the focus of 26 to 37 percent of all crops researchers.

Wheat. Ethiopia also accounted for a large share of wheat researchers and production value, but only a handful of countries are important wheat producers; Ethiopia, South Africa, Sudan, and Kenya accounted for more than 90 percent of the total value of wheat production and close to 80 percent of all FTE the region's wheat researchers in 2008.

Assessing the number of FTE researchers by major crop and country (Table 2) as a share of production (million metric tons, not production value) results in even wider variation across countries and crops. On average, wheat and maize attracted relatively more researchers (Figure 10). In 2008, on average, SSA employed 50 FTE wheat researchers and 30 FTE maize researchers per million metric ton of wheat and rice produced, respectively. The corresponding figures were 20 FTEs for rice, 10 FTEs for maize, and 3 FTEs for cassava. There is, however, large variation among the major countries within crops, especially for rice and sorghum. This is mostly the result of the high share of researchers focusing on rice in Ethiopia and on sorghum in Eritrea, Kenya, Zambia, and Botswana compared with corresponding production levels in these countries. More investigation is needed, however, to determine the reasons for these high intensities.

Figure 10. Full-time equivalent researchers per million metric tons of production, major crops and countries, 2008



Sources: Compiled by authors based on country-level ASTI survey data and FAO (2011).

Comparing shares of FTE researchers allocated to specific crops, livestock items, and subsectors with their respective shares of agricultural production volume or value can be a useful tool for policymakers; however, this measure has many shortcomings, including failing to incorporate many factors that affect agricultural R&D, such as differences in the likelihood of the success of the research, likely adoption rates, and the likely extent of research-induced productivity gains or spill-in of technologies from other countries (Alston, Norton, and Pardey 1998). In addition, this measure fails to consider differences in the costs, quality, or productivity of scientists across different crops and countries. The relatively high importance of rice research in Ethiopia is an example of how current investment in research will likely increase the value of rice production into the future. On the other hand, Ethiopia's prominence in a number of key crops under research does not take into account the reality that Ethiopian researchers are mostly only qualified to the BSc level, so the resulting research may have less impact than the impact generated by a smaller group of more highly trained and experiences researchers in another country. Measuring the intensity of specific research capacity on crops will become more important in the future in light of the high investments being made by the World Bank through the East and West Africa Agricultural Productivity Programs (EAAPP and WAAPP), which have been established to address the serious issue of fragmentation of agricultural research capacity in SSA evident in this paper.

In efforts to improve the effectiveness of agricultural research, resources are being channeled from selected national agricultural research institutes and programs into centers of specialization that have a regional mandate for a specific crop or subgroup of crops. Other countries will benefit from the spill-in effects of the outputs of these centers (Roseboom 2011). Given the scope of investments provided through World Bank loans and national government contributions, it is expected that crop research intensities for the crops included in EAAPP and WAAPP will shift considerably in the years to come.

7. CONCLUSION

Growth in numbers of agricultural researchers has accelerated by roughly 20 percent since 2000. In some countries, this growth resulted from long-term recruitment bans being lifted, whereas in other countries it was due to increased involvement in agricultural research by the higher education sector. As always, however, large differences occur across countries. Nigeria, and to a lesser extend Ethiopia, Kenya, and Sudan, were the main drivers of regionwide human capacity growth between 2001 and 2008. On the other hand, many of Africa's smaller countries, such as The Gambia, Gabon, or Sierra Leone, have only very small agricultural research systems. In a number of countries, agricultural research capacity has declined since the turn of the millennium, but in most African countries, female participation increased over the past decade. This was partly the result of various newly initiated institutional reforms and policies to promote gender equality in number of countries.

Agricultural research continues to be extremely fragmented, with most countries focusing on a large number of subsectors, such as crops, livestock, forestry, fisheries, and natural resources. Crops have remained the dominant subsector, but most countries focus their research efforts on a wide range of crops. No apparent specialization trends exist among the region's countries. The EAAPP and WAAPP programs funded through World Bank loans and government contributions were established to address these issues and improve the effectiveness of agricultural research in SSA. Nevertheless, it is too early to determine whether this objective will indeed be met. The World Bank programs have a limited time horizon, so this new direction will need strong ongoing commitment from national governments if the specialized capacity currently being developed is to be sustained and further built on over time.

A fundamental problem has yet to be overcome: the need for sustainable, long-term funding to ensure that short-term gains in human resource capacity can be maintained and exponentially built on so they can pay off in tangible research results over time. One thing is clear: evidence indicates that maximizing resources by overcoming existing fragmentation within agricultural research systems in SSA is a step in the right direction.

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The Agricultural Science and Technology Indicators (ASTI) initiative compiles, analyzes, and publishes data on levels and trends in agricultural R&D investments, capacities, and institutional arrangements in developing countries. ASTI is managed by the International Food Policy Research Institute (IFPRI) and involves collaborative alliances with many national and regional R&D agencies.

Jointly convened by ASTI/IFPRI and the Forum for Agricultural Research in Africa (FARA), the conference, "Agricultural R&D—Investing in Africa's Future: Analyzing Trends, Challenges, and Opportunities," brought together experts and stakeholders from the region to contribute their expertise for the purpose of distilling new insights and creating synergies to expand the current knowledge base. The themes under focus were (1) why African governments under invest in agricultural R&D; (2) how human resource capacity in agricultural R&D can be developed and sustained; (3) how institutional structures can be aligned and rationalized to support agricultural R&D; and (4) how the effectiveness of agricultural R&D systems can be measured and improved.

The conference was funded by the Bill and Melinda Gates Foundation and FARA.