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CHAPTER 5

Agricultural R&D: Is Africa Investing Enough?


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AGRICULTURAL R&D

Is Africa Investing Enough?

Nienke Beintema and Gert-Jan Stads

SUMMARY Given the goals of economic growth and poverty reduction, as well as the challenges of rapid population growth, climate change, and food price volatility, Africa south of the Sahara must invest in research and development (R&D) to boost agricultural productivity. This chapter provides a data-driven analysis of the region's recent progress in investing in financial resources and human resource capacity related to agricultural R&D.

Despite both unprecedented economic growth since the turn of the millennium and a steady decline in poverty rates in recent years, Africa south of the Sahara (SSA) remains the poorest region on the planet.[1] Agriculture is the mainstay in many SSA countries, serving as a significant source of employment. Although recent growth in gross domestic product (GDP) has brought some improvements to rural populations, many people living in rural areas remain in a state of poverty. Furthermore, the region will need to feed an additional 900 million people by 2050, according to estimates by the United Nations (UN).[2] To respond effectively not just to this rapid population growth but also to other pressing challenges—including climate change and rising and volatile food prices—SSA needs to accelerate its agricultural productivity without delay.

There is much evidence to show that over the past five decades investments in agricultural research and development (R&D) have tremendously enhanced agricultural productivity around the world.[3] By raising the quantity and quality of agricultural outputs, new technologies and varieties resulting from R&D investments have led to higher incomes, greater food security, better nutrition, and, ultimately, economic growth and poverty reduction. Little wonder that at their 2012 meeting in Mexico, the heads of state of the Group of 20 (G20) countries highlighted the importance of R&D in promoting agricultural productivity and food security and that the UN's post-2015 development agenda stresses the key role of R&D in increasing food production while protecting natural resources.[4]

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Private Investments on the Rise in Africa

CARL E. PRAY AND LATHA NAGARAJAN

Private investment in agricultural research and development (R&D) in Africa south of the Sahara has been limited to date—particularly compared with Asia and Latin America—but it is growing rapidly. We observe this increase especially in the seed industry. A recent study of five African countries—Kenya, Senegal, South Africa, Tanzania, and Zambia—estimated that about US$62 million was spent on private R&D.[1] Of this $62 million, $50 million was spent in South Africa.[2] About half of the private research is conducted by African firms, some of which are regional multinational corporations, such as Seedco based in Zimbabwe and Illovo based in South Africa. The other half was spent by multinational firms headquartered outside Africa, such as DuPont and Monsanto. The seed industry accounted for the largest share of R&D expenditure in all of the countries, followed by the plantation and processing industries, such as the sugar industry.

Among these five countries, private investment in agricultural R&D grew fastest in South Africa, doubling between 2001 and 2008. Two major reasons for this growth in South Africa were (1) the liberalization and privatization of the agricultural input and output markets and (2) the growing demand for modern agricultural inputs and food due to trade liberalization and economic growth elsewhere in Africa.[3]

Private agricultural R&D has led to increased yields of several important crops in Africa. The adoption of proprietary hybrids of maize increased yields in Tanzania.[4] Private sugarcane research in South Africa increased productivity there[5] and elsewhere in southern Africa. Many studies show that proprietary genetically modified maize and cotton improved the yields, incomes, and health of smallholder farmers in South Africa[6] and Burkina Faso.[7]

Private agricultural R&D in Africa is likely to grow faster than public sector R&D, which grew by one-third from 2000 to 2011.[8] The basis for this predicted private growth includes several factors:

1. Demand for agricultural products and processed goods will increase due to rapid economic growth.
2. The growth of public-sector research by national programs and international institutes in Africa provides opportunities for firms to create proprietary maize hybrids and other innovations.
3. Tariffs and technical barriers to trade in agricultural inputs are declining, and foreign investment is increasing.
4. The options for protecting intellectual property (such as hybrid plant varieties) and legal protection of intellectual property (such as patents) are growing stronger.

The key policies for African governments that want to encourage private-sector R&D and maximize its impact are support for public research, removal of barriers to trade in technology, continued liberalization and privatization of agribusiness, and strengthening of intellectual property rights.

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Global investment in agricultural R&D, once heavily weighted toward the developed world, has shifted dramatically in recent years toward the developing world. Whereas spending growth in high-income countries as a group has stalled to near-zero levels since the turn of the millennium, the developing world has accelerated its agricultural R&D investments at a rapid pace.[5] China and India alone accounted for about half the growth in global agricultural R&D spending during 2000–2008, and a number of other large middle-income countries (in particular, Argentina, Brazil, Iran, Nigeria, and Russia) significantly increased their spending levels.[6] R&D spending in low-income countries as a group also rose during this period, driven primarily by a number of larger East African countries.

Some encouraging signs indicate that African countries are increasingly focused on investing in agriculture for economic growth, evidenced by a number of influential initiatives and regional and subregional processes that have put agriculture and agricultural R&D firmly back on the political and donor agendas. Many countries have

developed solid agricultural development and financing plans to strengthen agricultural production and food security as part of the Comprehensive Africa Agriculture Development Programme (CAADP) of the New Partnership for Africa's Development (NEPAD). Another important move toward a stronger agricultural sector is the Science Agenda for Agriculture in Africa (S3A), which was initiated in early 2013 and is scheduled to be finalized and endorsed at the African Heads of State Summit in mid-2014.[7]

To achieve future growth targets, national governments in SSA will need to provide sufficient and stable financial and human resources adequate in both numbers and quality. Government support is required because research on agricultural commodities that have a large impact on smallholder income, food security, and poverty reduction generates knowledge, technologies, and other outputs that are considered public goods.[8] These public goods, by definition, have social benefits that are higher than the private benefits to individuals; they thus justify public intervention. Research conducted by the private sector, in contrast, is largely dictated by the profitability of investments and the appropriability of research returns. The private sector tends to ignore research areas that do not fulfill these two conditions.

Governments and donors in SSA need to allocate sufficient funds to the right types of agricultural R&D within not only a national but also a regional and subregional context. They must also ensure that farmers adopt the resulting innovations. National agricultural research systems cannot bring about success all alone, however; the CGIAR consortium, regional organizations, commodity networks, and the private sector also have an important role to play in releasing better varieties and technologies and ensuring their adoption.

This chapter takes stock of recent progress made in agricultural R&D investments and human capacity in SSA by using comprehensive datasets collected through primary surveys by IFPRI's Agricultural Science and Technology Indicators (ASTI) initiative and a network of national partners.[9]

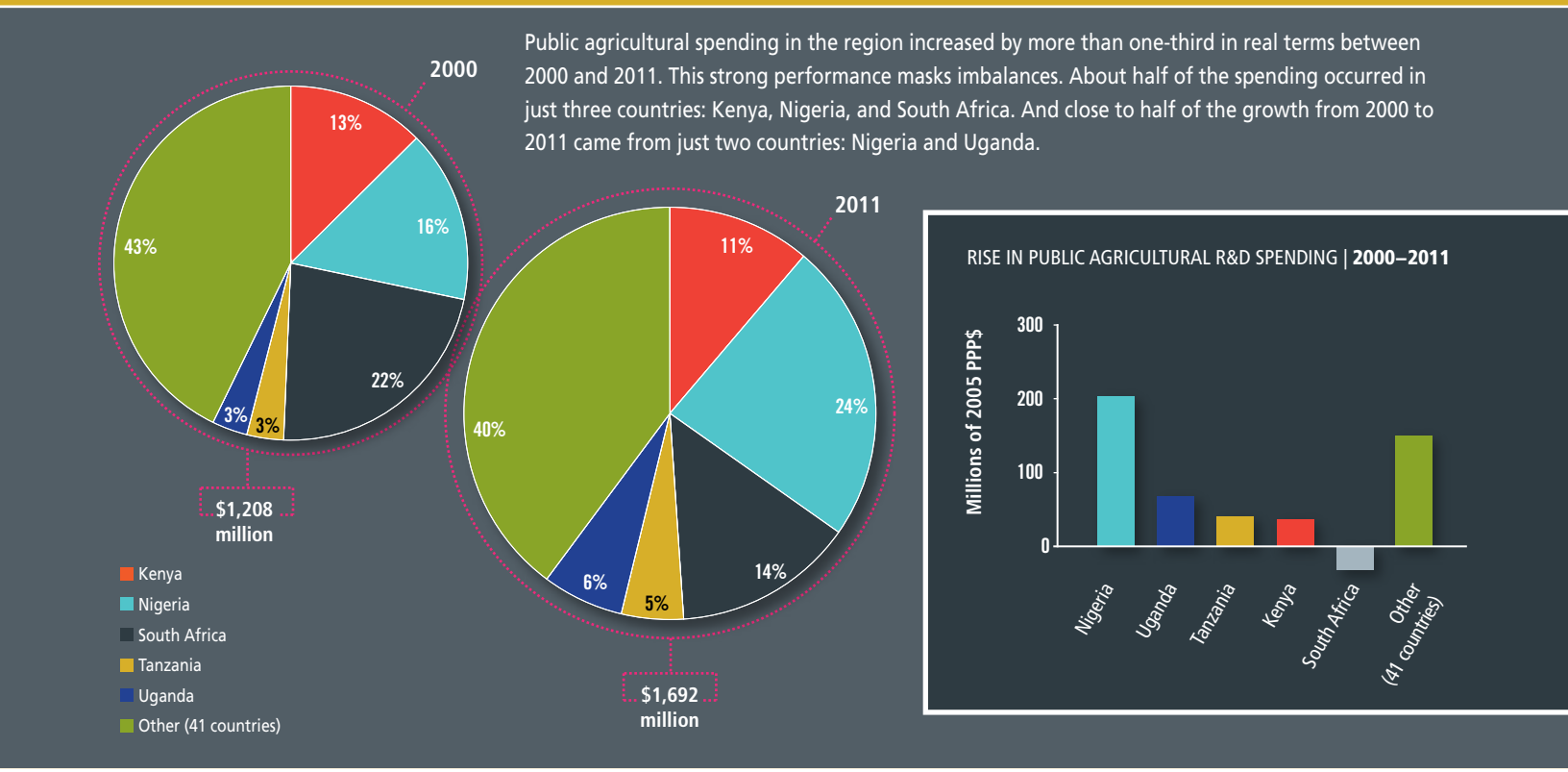
SPENDING INCREASED, BUT DONOR DEPENDENCY AND VOLATILITY REMAIN CRITICAL

Following a decade of stagnation during the 1990s, public agricultural R&D spending in SSA increased by more than one-third in real terms during 2000–2011, rising from $1.2 billion to $1.7 billion in 2005 constant purchasing power parity (PPP) dollars[10] or from $0.6 billion to $0.8 billion in 2005 constant US dollars (Figure 1).[11] Absolute spending levels varied considerably across countries. In 2011, Kenya, Nigeria, South Africa, and Uganda were the only countries that spent more than $100 million 2005 constant PPP dollars in agricultural R&D. On the other hand, roughly half the countries in the region reported investment levels below the $10 million mark.

The 2000–2011 growth in public agricultural R&D spending in SSA was driven mainly by a handful of larger countries. Close to half of this growth was attributable to increased spending in just two countries: Nigeria and Uganda. Ghana, Kenya, and Tanzania also recorded relatively high increases in total spending, each accounting for between 5 and 9 percent of total growth during 2000–2011. Growth was relatively consistent over time in Ghana, Kenya, Tanzania, and Uganda and resulted mostly from increased government funding combined, in some cases, with substantial additional resources provided by development banks (mostly the World Bank) and donors. In Nigeria, on the other hand, spending was erratic over time, as it was in many other countries in the region. Nigeria's public agricultural R&D spending, for example, more than doubled during 2000–2008 as a result of renewed government commitment to boosting scientist salary levels and investments in infrastructure and equipment. Government support has leveled off since then, however, resulting in an estimated drop in overall R&D spending of 3 percent during 2008–2011.[12]

Although increases and decreases in the absolute levels of agricultural R&D spending of a few countries in the region overshadow those of the others, a closer look at relative shifts in investment levels over time reveals some important cross-country differences. During 2000–2011,

FIGURE 1 PUBLIC AGRICULTURAL R&D SPENDING IN AFRICA SOUTH OF THE SAHARA, 2000 AND 2011 (IN 2005 PPP DOLLARS)



Source: Agricultural Science and Technology Indicators (ASTI) Database, www.asti.cgiar.org/data-graphics, forthcoming.

Notes: Regional total includes 45 of the 48 countries in Africa south of the Sahara: Equatorial Guinea, a high-income country, is excluded as are South Sudan and Somalia. For countries where data is unavailable—Angola, Cameroon, Comoros, São Tomé, and Príncipe—research spending and researcher capacity trends were estimated based on share of total agricultural output.

7 of 28 SSA countries for which a full set of time-series data was available experienced negative annual growth in public agricultural R&D spending, ranging from –1.2 to –13.6 percent a year. An additional 7 countries experienced near-zero growth rates (of between –0.9 and 0.2 percent a year).[13] This is a sizable number of countries given that spending in SSA as a whole actually increased substantially over this period. Some of the region's smallest, often francophone, countries have very low, volatile, and often declining long-term levels of investment and human resource capacity, which calls into question the effectiveness of their national agricultural R&D output. Nonetheless, some initial signs indicate that in more recent years, this negative cycle has been broken in an increasing number of smaller countries. Just looking at the 2008–2011 period (rather than the 2000–2011 period), 23 of the 33 countries for which full time-series data were available saw a rise in agricultural R&D spending. The 2007–2008 global food crisis and a number of influential initiatives, including the 2008 L'Aquila Food Security Initiative and CAADP, have put agriculture and agricultural research back firmly on the political and donor agendas and may be at the basis for this shift. In addition, starting in 2008, the World Bank–funded West Africa Agricultural Productivity Program, followed by the Eastern Africa Agricultural Productivity Project shortly afterward, injected significant funds into agricultural R&D in a number of countries throughout the region and contributed to overall R&D investment increases.

In addition to looking at absolute levels of agricultural R&D investment, another way of comparing commitment to public agricultural R&D investment across countries is to measure intensity—that is, total public agricultural R&D spending as a percentage of agricultural output (AgGDP).

A New Regional Push for Agricultural R&D in Africa

YEMI AKINBAMIJO

Will Africa achieve the first United Nations Millennium Development Goal (MDG1) of halving poverty by 2015? Success will depend largely on how agriculture affects national economies directly and on how it stimulates growth in other sectors. As Africa's population grows, continues to urbanize, and becomes more affluent, agriculture and its related value chains must grow even faster. Agriculture needs to chart Africa's path to sustainable economic growth and development, but this path requires increased investment.

Nowhere is this truer than in Africa's agricultural R&D systems, which have the most potential to effectively generate and disseminate technologies to transform agriculture. The agricultural success of Brazil, China, and India has been predicated in large part on their increased investments in agricultural R&D. Africa's current intensity of agricultural R&D investment (agricultural R&D spending as a share of agricultural gross domestic product) is 0.51—well below the target of 1 percent set by the New Partnership for Africa's Development. Africa needs higher levels of R&D investment to transform agriculture.

Overall, investment in Africa's agricultural R&D is rising. A few countries (Ethiopia, Ghana, Kenya, Nigeria, South Africa, Sudan, Tanzania, and Uganda) have relatively high levels of investment in agricultural R&D compared with other African countries; in others, however, investment remains low. *The Framework for African Agricultural Productivity*, a reference document for implementing the tenet on R&D spending set out by the Comprehensive Africa Agriculture Development Programme (CAADP), challenges African governments to invest prudently in R&D and to address problems of fragmentation and alignment. Many governments and development partners are now making long-term commitments through regional R&D initiatives and creating supportive policy environments for agricultural R&D. Global, regional, and national institutions and development partners are also playing a larger role in addressing agricultural R&D issues in ways that support CAADP targets.[1]

Key developments in 2013 involved consolidating these institutions' efforts to promote investments in regional and subregional agricultural R&D initiatives. For example, the Science Agenda for Agriculture in Africa (S3A), an initiative of several stakeholders,[2] is one of five work streams of the Dublin Process, currently being led by the Forum for Agricultural Research in Africa (FARA). The Science Agenda for Agriculture in Africa provides guidance on funding levels and priority areas of investment in science and makes the case for strengthening the people, institutions, and infrastructure required to transform Africa's agriculture. Contributing to this agenda is the regional agricultural productivity work stream, led by FARA, which seeks to align CGIAR Research Programs with the CAADP country process by developing agricultural R&D investment programs. Other R&D investment initiatives include the West Africa Agricultural Productivity Program, the Eastern Africa Agricultural Productivity Project, and the Agricultural Productivity Program for Southern Africa. These initiatives are led by subregional organizations and regional economic communities. They provide innovative and sustainable models by (1) focusing investments on priority agricultural sectors that have the greatest potential to stimulate growth, (2) establishing mechanisms for dissemination and adoption of technologies, and (3) leveraging spillover effects for a faster and wider impact on regional economic growth.

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Overall investment levels in most countries are still well below the levels required to sustain agricultural R&D needs. In 2011, SSA as a whole invested $0.51 for every $100 of agricultural output on average, which is well below NEPAD's 1 percent national R&D investment target. The 2011 intensity was comparable to the value recorded in 2000 but considerably lower than values recorded in more recent years, which indicates that growth in agricultural R&D spending, though substantial, has not kept pace over the past few years with growth in agricultural output. In 2011, just 10 of the 39 countries for which agricultural R&D intensity ratios were available met the 1 percent target (Figure 2). In contrast, 18 countries recorded intensity ratios lower than 0.5. While intensity ratios

do provide useful insights into relative investment levels across countries and over time, they do not take into account the policy and institutional environment within which agricultural research occurs, the broader size and structure of a country's agricultural sector and economy, or the qualitative differences in research performance across countries. Small countries, for example, may require relatively

The New Face of Agricultural Extension Services

KRISTIN DAVIS

Agricultural extension services are back on the development agenda. Extension provides information and services required by farmers and other actors in rural settings for developing their own technical, organizational, and management skills.[1] Extension services had a heyday in the 1980s and early 1990s, when money was poured into systems that promoted agricultural technologies, mainly in a top-down, one-size-fits-all fashion. In the late 1990s, when many of these systems were shown to be ineffective, spending on extension declined.[2] Now, however, extension services are being viewed from a broader systems perspective. New tools for providing information and services are available, and new roles and capacities are required for extension services to meet the challenges facing rural people and systems.

These new aspects of extension were subjects of international meetings and reports in late 2012 and in 2013.[3] Several of these were direct outgrowths of a position paper called *The New Extensionist* that was published in 2012 by the Global Forum for Rural Advisory Services (GFRAS), an international group involved in advocacy and leadership on extension services.[4] This work described the new roles to be played by extension services and called for improving not only individual capacity but also the capacity of extension organizations and systems. It noted the increasingly important role of the private sector and civil society organizations, together with the public sector. In addition to promoting agricultural innovations, extension services are now being asked to contribute to improving nutrition, reducing risk and enhancing the resilience of rural livelihoods, and peacebuilding, among other things. Extension systems must make use of new information and communication technologies.[5]

In the face of these new demands and realities, a number of national governments have renewed their focus on extension policies and programs. For example, Kenya, Liberia, South Africa, and South Sudan have recently drafted extension policies.[6] These policies, which were all developed through participatory consultation, focus on strengthening farmers' voices. Most take a systems approach, promote pluralism, and rely on the public sector to play the necessary role of coordinating and regulating. Bangladesh and Ethiopia are training staff and developing new programs for extension.[7] A 2013 study of 15 countries in Latin America and the Caribbean showed that public funding for extension has rebounded in the region and that extension services have become increasingly driven by demand, based on a business model, reliant on information and communication technologies, and cofinanced.[8]

A coalition of actors recently completed a worldwide study of extension system programs and human and financial resources.[9] The study showed that there is a huge number of public, private, and civil society actors providing services globally, but that it is difficult to continuously update the data because of the pluralism and decentralization of government services.

As extension services seek to meet new demands, more research is needed to shed light on how extension can contribute most effectively to rural development. Currently, research on extension is fragmented and inadequate to support evidence-based policymaking. The IFPRI-led CGIAR Research Program on Policies, Institutions, and Markets is seeking to deepen understanding of how to strengthen extension systems.[10] The program will start with a historic overview of reforms of extension systems and frameworks, a study on operationalizing the "best fit approach,"[11] and a contribution on monitoring and evaluating extension.

Extension services are back. But they run the risk of being viewed once again as ineffective if they are stretched too thin by the great expectations of the development community. With the recognition of the systemic nature of rural development and the use of tailored best-fit approaches for different client groups and policy contexts, there is tremendous potential for extension services. However, we need to better understand and document the impact that extension services have on rural development outcomes.

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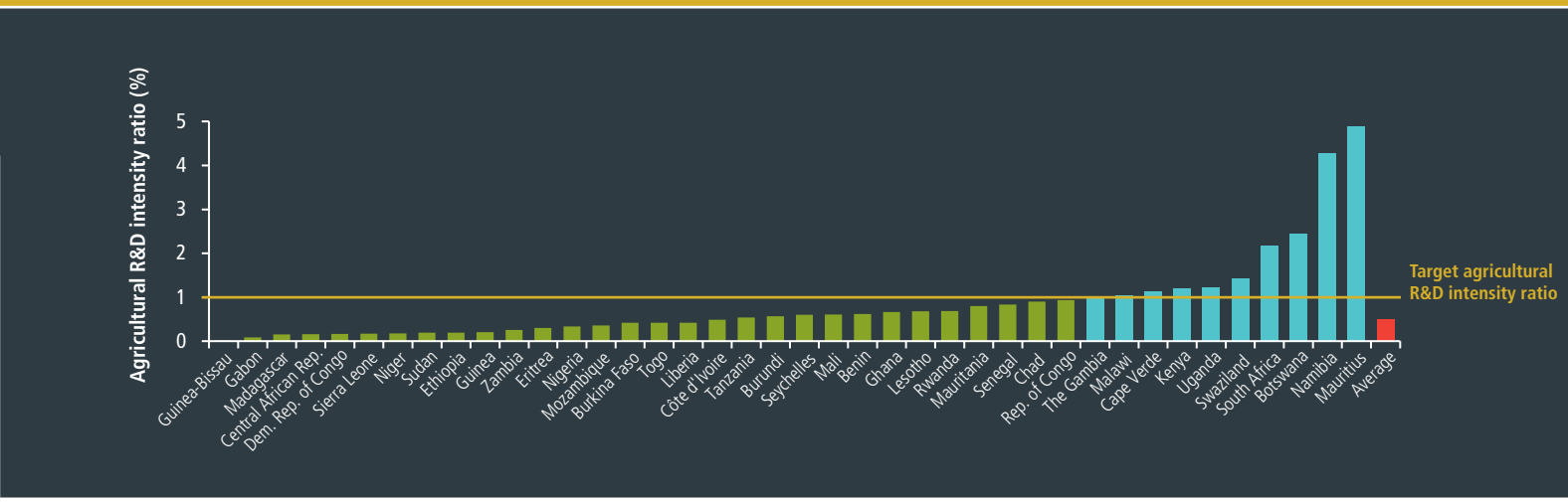
FIGURE 2 AGRICULTURAL R&D INTENSITY RATIOS BY COUNTRY, 2011



Source: ASTI Database, www.asti.cgiar.org/data-graphics, forthcoming.

more human resource and capital investments because they are unable to benefit from the economies of scale available to larger countries. Equally, countries with greater agricultural diversity may have more complex research needs, requiring higher funding levels.

Agricultural R&D investment is positively associated with high returns, but these returns take time—commonly decades—to develop. Consequently, the inherent lag from the inception of research to the adoption of a new technology or the introduction of a new crop variety calls for sustained and stable R&D funding. As Nigeria's experience shows, agricultural R&D funding in many SSA countries has been far from stable over time, and agricultural R&D spending in the region overall has been more volatile than in other developing regions. Research agencies in SSA, particularly those in low-income countries, are highly dependent on funding from donors and development banks, and this type of funding has been considerably more volatile than government funding over the past decade. These agencies thus often fall into financial crisis upon the completion of large donor-funded projects, forcing them to cut research programs and lay off staff. In addition, too much of the critical decisionmaking about research priorities is sometimes devolved to donors and development banks. As a result the research agendas of many agricultural research agencies across SSA—particularly in smaller, low-income countries—are skewed toward short-term goals that are not necessarily aligned with national and regional or subregional priorities.[14]

INCREASE IN RESEARCHER QUANTITY BUT NOT QUALITY

SSA needs talented, well-trained, and highly motivated research staff to generate the high-quality research outputs that are necessary to accelerate growth in the agricultural sector.[15] During 2000–2011, researcher capacity in SSA increased by roughly 50 percent to an estimated 14,300 agricultural researchers, in full-time equivalents (FTEs).[16] The participation of female scientists has increased in many countries; the number of researchers with doctorate (PhD) and master of science (MSc) degrees has also risen considerably in absolute numbers, though average researcher qualifications varied across countries (Table 1). PhD holders in only 5 of the 36 countries for which a complete set of degree-level data are available (Botswana, Benin, Burkina Faso, Madagascar, and Senegal) exceeded 40 percent of the total number of researchers, whereas another 6 countries reported PhD shares of 10 percent or lower.[17]

The lack of a critical mass of PhD-qualified scientists poses significant constraints to conducting high-quality research and attracting external funding. No researchers with PhD or MSc degrees

TABLE 1 Share and age distribution of researchers with doctorate (PhD) degrees by country, 2011

Country	Share of PhD holders in total number of researchers (%)	Share of PhD holders older than 50 (%)
Senegal	70	38
Benin	55	57
Burkina Faso	47	29
Swaziland	43	75
Madagascar	42	65
Ghana	36	60
Sudan	35	48
Mali	33	82
Kenya	32	55
Republic of Congo	31	74
Togo	31	71
Uganda	31	45
Nigeria	25	54
Mauritania	25	23
Gabon	20	37
Tanzania	20	49
Botswana	20	45
Malawi	20	31
Burundi	18	18
Sierra Leone	17	74
Chad	17	56
Guinea	16	95
Central African Republic	14	50
Mauritius	13	45
Namibia	13	61
Democratic Republic of Congo	13	61
Zimbabwe	12	28
Rwanda	12	28
Eritrea	11	75
Liberia	11	71
Cape Verde	10	0
Ethiopia	9	43
Lesotho	9	76
The Gambia	9	47
Mozambique	8	27
Guinea-Bissau	0	0

Source: ASTI Database, www.asti.cgiar.org/data-graphics, forthcoming.

Notes: Data for Nigeria include the national agricultural research institutes under the Agricultural Research Council of Nigeria only; age data for Burkina Faso, Malawi, Senegal, Sudan, and Tanzania exclude the higher-education sector.

are active in Guinea-Bissau, for example, and in 2011, the national agricultural research institutes in Burundi and The Gambia employed just one and two PhD-level scientists, respectively.[18] This finding highlights the necessity of regional initiatives focusing on the needs and vulnerabilities of small countries. A recent expert panel report, produced as part of the S3A process, calls on African leaders to, among other things, ensure minimal agricultural R&D capacity in all SSA countries, support regional centers of excellence to share knowledge and research facilities, and contribute to a regional science fund.[19]

Despite rapid growth in the total number of agricultural researchers in SSA, many countries continue to face serious capacity constraints. Long-term public-sector recruitment restrictions have resulted in an aging pool of researchers in a number of countries. This trend has left agencies in these countries highly vulnerable. As many senior staff approach retirement, midlevel researchers who can take on seniority roles and mentor the next generation of junior scientists are often lacking. In addition, low salary levels, poor conditions of service, and subpar facilities have led to high staff turnover in many countries.[20] Evidence on the exact nature and scope of staff turnover, however, is sketchy. To help address this information gap, ASTI collected detailed information on the age distribution of researchers by degree for 36 countries (Table 1). In 17 countries more than half of the researchers holding a PhD degree were older than 50, whereas in 9 countries the share of PhD holders older than 50 was higher than 70 percent. The situation is particularly severe in West Africa. These findings highlight the acute need to recruit and train the next generation of scientists.

Given high staff turnover, large numbers of retiring senior researchers, and various recruitment restrictions, the rapid R&D capacity growth over the past decade has largely been driven by the recruitment of junior researchers (often having only a bachelor's degree, BSc), particularly during 2000–2008. In fact, although the number of PhDs increased in absolute terms from 2008 to 2011, the overall share of PhD holders in total agricultural R&D staff for a sample of 28 countries for which

long-term data on researchers by degree were available (excluding, among others, South Africa) fell from 31 percent in 2008 to 29 percent in 2011.[21] A worrisome trend is that 12 of the 28 sample countries reported a decline in the absolute number of researchers with PhD degrees during the same period.[22]

Notwithstanding the numerous human resource challenges that many SSA countries continue to face, there have also been many positive developments in recent years. In an attempt to halt staff turnover, some countries have put in place new measures, including large-scale recruitment after years of neglect, the boosting of scientist and support staff salaries to more competitive levels, increases in retirement age, improved benefits packages, and the establishment of performance appraisal systems and promotion opportunities based on merit rather than seniority. New donor-funded capacity-building initiatives have also arisen in recent years (these had been a major source of funding for staff training during the 1970s and 1980s but had been cut or reduced by many donors in the 1990s). Many donors acknowledge the need to not only increase funding for agricultural research but also invest in human capital. Such initiatives include the capacity-strengthening components of the West Africa Agricultural Productivity Program, the Eastern Africa Agricultural Productivity Project, the Alliance for a Green Revolution in Africa, and the Regional Universities Forum for Capacity Building in Agriculture.

CONCLUSION

Given the challenges that SSA is facing in terms of rapid population growth, climate change, and food price volatility, it is crucial that agricultural productivity in the region be further increased. Agricultural R&D in SSA is at a critical crossroads. Although the past few years have been characterized by positive developments and ambitious goals and processes, these advances will need to be further accelerated and scaled up. The 2013 high-level report on agriculture and food systems by the UN Sustainable Development Solutions Network has put forward a number of goals to replace the Millennium Development Goals.[23] Specifically, the group has called for a minimum of 5 percent annual growth in agricultural R&D spending in low- and middle-income countries over the next decade and allocation of at least 1 percent of agricultural GDP to public agricultural R&D.[24] Given SSA's annual spending growth rate of 2.7 percent in 2000–2011 and its agricultural R&D intensity ratio of 0.51 percent in 2011, investments in agricultural R&D would need to double over the next decade if these ambitious targets are to be achieved.

As many senior staff approach retirement, midlevel researchers who can take on seniority roles and mentor the next generation of junior scientists are often lacking.

Success in building on recent progress and in achieving future growth targets is profoundly dependent on sufficient and stable financial resources and on human resource capacity of adequate quantity and quality. Researchers also need appropriate incentives to pursue productive research careers in SSA, including attractive salaries, good research facilities and support services, and management systems that reward high-quality work. Public research institutions across the region will need to be further transformed by attracting, maintaining, and effectively using expertise and by securing more diverse funding sources, including relatively untapped sources in the private sector. National governments need to identify their long-term national R&D priorities more clearly and design relevant, focused, and coherent R&D programs accordingly. Donors will need to align their funding strategies more closely with national R&D priorities; countries' CAADP investment plans can be used to expedite this process. Finally, stronger partnerships linking national agricultural research actors with each other, with subregional organizations, and with CGIAR will help maximize opportunities for cross-country synergies. ■

NOTES

CHAPTER 5

1 World Bank, "World Development Indicators Database," accessed December 12, 2013, http://data.worldbank.org/data-catalog/world-development-indicators.

2 United Nations Sustainable Development Solutions Network (UNSDSN), *Solutions for Sustainable Agriculture and Food Systems: Technical Report for the Post-2015 Development Agenda* (New York: United Nations, 2013).

3 J. Alston, C. Chan-Kang, M. Marra, P. Pardey, and T. Wyatt. *A Meta-Analysis of Rates of Return to Agricultural R&D: Ex Pede Herculem?* IFPRI Research Report 113 (Washington, DC: International Food Policy Research Institute, 2000); J. Alston, *The Benefits from Agricultural Research and Development, Innovation, and Productivity Growth,* OECD Food, Agriculture, and Fisheries Working Paper 31 (Paris: Organisation for Economic Co-operation and Development, 2010); World Bank, *World Development Report 2008* (Washington, DC: 2007); A. Alene, A. Menkir, S. Ajala, B. Badu-Apraku, A. Olanrewaju, V. Manyong, and A. Ndiaye, "The Economic and Poverty Impacts of Maize Research in West and Central Africa," *Agricultural Economics* 40 (2009): 535–550.

4 UNSDSN, *Solutions for Sustainable Agriculture and Food Systems*.

5 Agricultural research and development (R&D) in developing countries receives support not only from national agricultural research activities but also from the CGIAR Consortium. After more than a decade of slow growth, CGIAR accelerated its R&D spending starting in 2006. In 2011, total spending by CGIAR exceeded US$700 million, a 41 percent increase from 2006 in inflation-adjusted terms.

6 N. M. Beintema, G. J. Stads, K. Fuglie, and P. Heisey, *ASTI Global Assessment of Agricultural R&D Spending: Developing Countries Accelerate Investment* (Washington, DC, and Rome: International Food Policy Research Institute and Global Forum on Agricultural Research, 2012).

7 Forum for Agricultural Research in Africa (FARA), *Science Agenda for Agriculture in Africa (S3A): "Connecting Science": A Science Agenda for Transforming Agricultural in Africa* (report of an expert panel, Accra, Ghana, 2013, draft).

8 D. L. Umali, *Public and Private Sector Roles in Agricultural Research: Theory and Experience,* Discussion Paper 176 (Washington, DC: World Bank, 1992); P. Pinstrup-Andersen, "Is Research a Global Public Good?" *Entwicklung + Ländlicher Raum* 34, no. 2 (2000); C. E. Pray, D. Johnson, and K. O. Fuglie, "Private Sector Research," in *Handbook of Agricultural Economics 3: Agricultural Development: Farmers, Farm Production, and Farm Markets,* edited by R. E. Evenson and P. Pingali (Amsterdam: Elsevier, 2007).

9 ASTI datasets are collected and processed using internationally accepted definitions and statistical procedures for compiling R&D statistics developed by the Organisation for Economic Co-operation and Development and the United Nations Educational, Scientific, and Cultural Organization. To facilitate cross-country comparisons, all financial data have been converted to 2005 purchasing power parity (PPP) prices, which measure the relative purchasing power of currencies across countries by eliminating national differences in pricing levels for a wide range of goods and services. For more information on ASTI's methodology, see www.asti.cgiar.org/methodology.

10 All dollar values in this chapter are in 2005 constant PPP dollars, unless otherwise specified.

11 ASTI (Agricultural Science and Technology Indicators), ASTI Database, www.asti.cgiar.org/data (Washington, DC: International Food Policy Research Institute, forthcoming).

12 Ibid.

13 Ibid.

14 G. J. Stads, "Africa's Agricultural R&D Funding Rollercoaster: An Analysis of the Elements of Funding Volatility," Conference Working Paper 2, prepared for ASTI/IFPRI–FARA Conference "Agricultural R&D: Investing in Africa's Future—Analyzing Trends, Challenges, and Opportunities," Accra, Ghana, December 5–7, 2011.

15 J. Anderson and J. Roseboom, *Towards USAID Re-engaging in Supporting National Agricultural Research Systems in the Developing World* (Washington, DC: US Agency for International Development, 2013).

16 ASTI, ASTI Database.

17 It is important to note that not every country defines *researcher* the same way. In some countries, the minimum requirement is a master's degree, whereas in other countries a bachelor's degree suffices.

18 In fact, the Institut des Sciences Agronomique du Burundi (ISABU) had its last remaining PhD-qualified scientist depart the institute in 2012. Currently, four ISABU researchers are pursuing PhD training abroad and are expected to return to Burundi in the near future. G. J. Stads, L. Ndimurirwo, and L. V Magne Domgho, *ASTI Factsheet: Burundi* (Washington, DC, and Bujumbura, Burundi: International Food Policy Research Institute and Institute of Agricultural Science of Burundi, 2013).

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A New Regional Push for Agricultural R&D in Africa

1 The institutions include CGIAR, the Forum for Agricultural Research in Africa (FARA), subregional organizations, national agricultural research systems, the African Forum for Agricultural Advisory Services, the Regional Universities Forum for Capacity Building in Agriculture, and the African Network for Agriculture, Agroforestry, and Natural Resources Education.

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