ASTI Agricultural Science & Technology Indicators

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BENCHMARKING AGRICULTURAL RESEARCH INVESTMENT AND CAPACITY INDICATORS ACROSS SOUTHERN AFRICAN COUNTRIES

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INTRODUCTION

Extensive empirical evidence demonstrates that agricultural research and development (R&D) investments have greatly contributed to economic growth, agricultural development, and poverty reduction in developing regions over the past five decades (World Bank 2007; IAASTD 2008). Given important challenges, such as rapid population growth, adaptation to climate change, water scarcity, and the volatility of prices in global markets, policymakers are increasingly recognizing the value of greater investment in agricultural R&D as an essential element in increasing agricultural productivity in Sub-Saharan Africa (SSA).

The 2003 Maputo Declaration directed all member countries of the African Union (AU) to increase agricultural investments to at least 10 percent of their national budgets. To gauge progress toward this target, the Comprehensive Africa Agriculture Development Programme (CAADP) under the AU's New Partnership for Africa's Development (NEPAD) agreed to monitor agricultural expenditures, setting a 6 percent yearly target for growth in agricultural gross domestic product (AgGDP) in countries where agriculture plays a dominant economic role. One of CAADP's four foundational pillars focuses on increasing investments in agricultural research, extension, education, and training as a means of promoting growth in agricultural productivity (NEPAD–CAADP 2010). Moreover, NEPAD's African Ministerial Council on Science and Technology (AMCOST) established and adopted a Consolidated Plan of Action for developing regional science and technology (S&T). This plan calls for substantial increases in national R&D budgets, with each country taking concrete measures to allocate at least 1 percent of its gross domestic product (GDP) to R&D (NEPAD 2006).

In order to measure, monitor, and benchmark the inputs, outputs, and performance of agricultural S&T systems at the national and regional levels and to assess progress toward the successful implementation of CAADP and AMCOST targets related to S&T, quantitative data are essential. S&T indicators are an indispensable tool when assessing the contribution of agricultural S&T to agricultural growth and, more generally, to economic growth. They assist research managers and policymakers in formulating policy and making decisions about strategic planning, priority setting, monitoring, and evaluation. They also provide information to governments and others involved in the public debate on the state of agricultural S&T at national, regional, and international levels.

This brief assesses trends in investments and human resource capacity in public agricultural R&D in 10 of the 15 member countries of the Southern African Development Community (SADC): Botswana, Madagascar, Malawi, Mauritius, Mozambique, Namibia, South Africa, Tanzania, Zambia, and Zimbabwe (unfortunately, data for Angola, the Democratic Republic of Congo, Lesotho, Seychelles, and Swaziland were not available).[1] The analysis draws from a set of country notes prepared by the Agricultural Science and Technology Indicators (ASTI) initiative of the International Food Policy Research Institute (IFPRI) and national partners, using comprehensive datasets derived from primary surveys conducted during 2009–10.[2] These datasets have been linked with previously collected investment and human resource data.[3] This brief focuses on benchmarking the various ASTI indicators across SADC countries, and as such complements ASTI's in-depth country notes published during 2010–11 and its analytical report for SSA as a whole (Beintema and Stads 2011a).

LONG-TERM INVESTMENT AND CAPACITY TRENDS

After a decade of stagnation during the 1990s, investments and human resource capacity in public agricultural R&D averaged more than 20 percent growth in SSA during 2001–08. Most of this growth, however, occurred in only a handful of countries and was largely the result of increased government commitments to augment incommensurately low salary levels and to rehabilitate infrastructure, often after years of underinvestment. In contrast, many countries still face fundamental capacity and investment challenges. For some, national investment levels have fallen so low as to leave them dependent on often volatile, external funding sources (Beintema and Stads 2011a).

Box 1—Measuring agricultural R&D resources

The concept of purchasing power parity (PPP) prices

Comparing R&D data is a highly complex process due to important differences in price levels across countries. The largest components of a country's agricultural R&D expenditures are staff salaries and local operating costs, rather than capital investments that are traded internationally. For example, the wages of a field laborer or lab assistant at a research facility are much lower in Kenya than in any European country, and locally made office furniture in Ethiopia is considerably cheaper than a similar set of furniture bought in the United States.

Standard market exchange rates are the logical choice for conversions when measuring financial flows across countries. However, they are far from perfect currency converters for comparing economic data. At present, the preferred conversion method for calculating the relative size of economies or other economic data, such as agricultural R&D spending, is the purchasing power parity (PPP) index. PPPs measure the relative purchasing power of currencies across countries by eliminating national differences in pricing levels for a wide range of goods and services. They are also used to convert current GDP prices in individual countries to a common currency. In addition, PPPs are relatively stable over time, whereas exchange rates fluctuate considerably (for example, the fluctuations in the US dollar–euro rates of recent years).

The concept of full-time equivalent (FTE) researchers

ASTI bases its calculations of human resource and financial data on full-time equivalent staffing, or FTEs, which take into account the proportion of time researchers spend on R&D activities. University staff members, 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.

Sources: Beintema and Stads (2008, 2011b forthcoming) and ASTI's website (www.asti.cgiar.org/methodology).

These overall regional trends also apply to the Southern African countries that form the focus of this study, although most countries have relatively less serious capacity and investment challenges than their counterparts in West and Central Africa. Total investments in public agricultural R&D in the SADC countries included in this study increased slightly from an average of $480 million in the 1990s to $492 million in 2008, measured in inflation-adjusted purchasing power parity (PPP) dollars (see Box 1 for an explanation of PPPs). Absolute levels of public agricultural R&D spending and staffing varied considerably across the countries (Table 1). In 2008, South Africa and Tanzania invested $272 million and $77 million in agricultural R&D, respectively, whereas Madagascar and Zambia spent $12 million and $8 million, respectively. The 2008 distribution of research staff by country follows a similar pattern, with South Africa and Tanzania each employing more than 600 full-time equivalent (FTE) researchers, and Botswana and Namibia employing fewer than 100 FTEs each (see Box 1 for an explanation of FTEs). In 2008, the 10 SADC countries combined spent $492 million 2005 PPP dollars on public agricultural R&D and employed about 2,700 FTE researchers, accounting for 28 percent of total SSA spending and 23 percent of total SSA research capacity. The difference in shares indicates that, on average, SADC countries have slightly higher spending levels per researcher than the remainder of SSA.

Considerable differences were reported not only in absolute investment levels among the SADC countries, but also in the magnitude of growth over time. During 2001–08, four countries, Mauritius, Mozambique, Namibia, and Zambia, experienced negative growth in public agricultural spending of –2 to –4 percent per year. In contrast, four other SADC countries reported positive yearly growth, ranging from very low (0.4 percent for South Africa), to moderate (3 and 4 percent for Botswana and Madagascar, respectively), to very high rates (11 percent for Tanzania). Overall, the average combined growth in the investment rate for the 10 SADC countries during 2001–08 was lower than the comparable average of 2.4 percent for SSA as a whole.

Growth in agricultural research staffing varied across countries as well. Research capacity in Mozambique increased substantially during 2004–08 as a result of rehabilitation after years of civil unrest. The number of agricultural researchers employed in Botswana also grew substantially from the 1990s in terms of FTEs, although levels dropped abruptly in 2008. In contrast, after significant contractions in research capacity in Zambia due to a hiring freeze during the 1990s, growth resumed in 2006. South Africa, the subregion's largest employer of agricultural researchers, also reported a decline, from more than 1,000 FTEs in the late-1990s to fewer than 800 in 2008. Negative growth occurred in Malawi and Zimbabwe as well. During 2001–08, research staffing remained relatively constant or slightly increased in the remaining countries (Madagascar, Mauritius, Namibia, and Tanzania).

Table 1—Public agricultural R&D spending and staffing, 1991–2008

1A. R&D spending

Country	Total 2005 PPP dollars (million)				Annual growth rate (%)		
	1991–95	1996–2000	2001–05	2008	1991–96	1996–2001	2001–08
Botswana	12	16	19	19	3.6	12.4	2.9
Madagascar	na	15	10	12	–7.9	–14.5	4.3
Mauritius	15	21	29	22	5.0	7.6	–4.4
Mozambique	na	na	13	18	na	na	–2.3
Namibia	na	na	25	22	na	na	–2.4
South Africa	287	306	281	272	3.1	–2.6	0.4
Tanzania	na	38	41	77	na	7.0	10.7
Zambia	21	21	9	8	–3.5	–19.4	–2.9
Subtotal (10)	468	495	476	492	0.6	–1.7	1.2
SSA total	**1,258**	**1,247**	**1,487**	**1,727**	**–1.3**	**3.6**	**2.4**

1B. R&D staffing

Country	Total number of researchers (FTE)				Annual growth rate (%)		
	1991–95	1996–2000	2001–05	2008	1991–96	1996–2001	2001–08
Botswana	44	59	76	97	8.7	6.9	5.6
Madagascar	189	204	209	212	2.9	1.0	0.3
Malawi	162	165	133	127	–3.2	–2.5	–1.7
Mauritius	120	148	151	158	5.0	0.0	1.7
Mozambique	na	na	121	263	na	na	11.7
Namibia	na	na	61	70	na	na	0.2
South Africa	998	1,034	835	784	2.1	–3.2	–1.7
Tanzania	526	523	639	674	–1.1	2.8	1.4
Zambia	195	196	146	209	3.2	–8.1	3.8
Zimbabwe	na	na	154	148	na	na	–1.5
Subtotal (10)	2,573	2,619	2,527	2,742	1.0	–1.5	1.4
SSA total	**9,001**	**9,369**	**10,404**	**12,102**	**1.2**	**1.2**	**2.8**

Sources: Compiled by author based on country-level ASTI survey data, several secondary resources, and Beintema and Stads 2011a. For more information, see the individual ASTI Country Notes available at www.asti.cgiar.org.

Notes: Calculations are based on five-year averages, with the exception of 2008. See the individual ASTI Country Notes for agency and coverage. The subtotal for the 10 SADC countries include estimates for Malawi for 1991–2008 (spending), for Mozambique for 1991–2003 (spending and staffing), for Namibia for 1991–2000 (spending and staffing), and for Zimbabwe for 1991–2008 (spending) and 1991–2000 (staffing); na indicates that data were not available.

Recent key trends by country

As was indicated by the growth rates discussed in the previous section, each country recorded varying capacity and spending trends after the turn of the millennium. These are briefly discussed below.

Botswana. Greater government funding drove significant growth in national agricultural research investments and capacity in Botswana during 1995–2007. Thereafter, investment and capacity levels fell due to inflation, as well as high staff turnover at the main agricultural research agency, the Department of Agricultural Research (DAR). Due to low government salaries, retaining staff is a significant issue at DAR (Stads and Pholo 2011).

Madagascar. The completion of a large World Bank–funded project in 1999 prompted a sudden decline in Madagascar's overall agricultural R&D expenditures. Spending levels have recovered somewhat in more recent years as a result of in-kind technical support from France. Despite important institute-level shifts, Madagascar's national agricultural research capacity remained relatively unchanged during 2001–08 (Stads and Randriamanamisa 2010).

Mauritius. Mauritius has consistently ranked highly in terms of its intensity of agricultural research investment as a share of its agricultural output levels (4 percent in 2008), reflecting the country's leading role in sugarcane research. Nevertheless, public investment levels have declined since 2002 due to lower production and world prices of sugar. A tax on sugar exports funds the country's largest agricultural R&D agency, the Mauritius Sugar Industry Research Institute (MSIRI) (Rahija, Ramkissoon, and Stads 2010).

Mozambique. Post–civil war efforts to rebuild Mozambique's agricultural research capacity have led to increases in researcher numbers, although new staff tend to be younger and less well qualified in terms of postgraduate training. The country's agricultural R&D depends on unstable donor funding, and even government support for research activities fell between 2004 and 2008 (Flaherty, Mazuze, and Mahanzule 2010).

Namibia. Like Botswana, agricultural R&D in Namibia is primarily funded by the government, and donor support is minimal. Despite yearly fluctuations, overall investment levels changed little between 2001 and 2008. The country's major constraint to agricultural R&D is the low level of postgraduate qualifications among its agricultural researchers (Ipinge, Rahija, and Stads 2011).

South Africa. South Africa has one of the most well-established and well-funded research systems in SSA. Nevertheless, yearly public agricultural R&D expenditures varied significantly during 2000–08 due to fluctuations in government funding to the Agricultural Research Council (ARC), the country's main agricultural R&D agency. The number of agricultural researchers declined by one-third between 1997 and 2004, and capacity increased only slightly thereafter (Flaherty, Liebenberg, and Kirsten 2010).

Tanzania. Tanzania's agricultural R&D system has traditionally been highly dependent on donor funding and development bank loans, which fluctuated considerably from year to year. From 2005, after years of comparatively low investment, the government increased its support to agricultural research, especially during 2008. Total agricultural research capacity has grown slightly in recent years, with most of the growth taking place in the higher education sector (Flaherty and Lwezaura 2010).

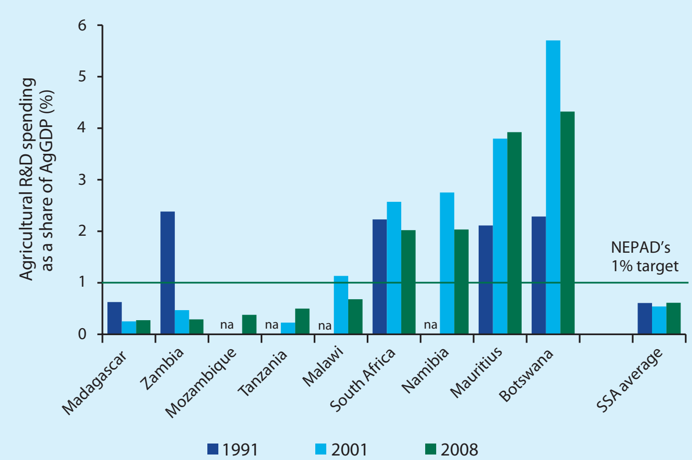
Zambia. Zambia's long-term trend of declining public agricultural R&D investments accelerated during 2001–08. Levels of government and donor support have dropped considerably compared with levels recorded in the 1980s and 1990s. Meanwhile, research capacity was eroded due to a civil service hiring freeze and a general lack of training opportunities in the government sector. Average qualification levels in terms of MSc and PhD degrees deteriorated considerably across all agencies (Flaherty and Mwala 2010).

Zimbabwe. The country's economic decline has greatly reduced the amount of government funding directed toward agricultural research since 2000. In the past, donors had also contributed a large share of funding, but most had withdrawn from the country by 2003. The effect of hyperinflation on salaries and in turn on agencies' ability to retain staff led to erosion in human resource capacity and qualification levels compared with other countries in the region (Flaherty, Chipunza, and Nyamukapa 2011).

BENCHMARKING KEY INVESTMENT INDICATORS

Spending intensity. Analyzing absolute levels of research expenditures explains only so much. Another way of comparing the commitment to public agricultural R&D investments across countries is to measure total public agricultural R&D spending as a percentage of AgGDP (Figure 1). This relative measure indicates the intensity of investment in agricultural research, not just the

Figure 1—Intensity of agricultural R&D spending by country, 1991, 2001, 2008



Sources: Compiled by author based on country-level ASTI survey data and several secondary resources (see individual ASTI Country Notes). AgGDP data are from World Bank 2010.

Note: Intensity ratios were not available for Zimbabwe; for Mozambique for 1991 and 2001; and for Tanzania, Malawi, and Namibia for 1991.

absolute level of spending. In 2008, four of the countries with the highest intensity ratios across SSA were Southern African countries: Botswana (4.3), Mauritius (3.9), Namibia (2.0), and South Africa (2.0). These countries were also the only ones in the SADC group with ratios above NEPAD's national R&D investment target of at least 1 percent of GDP. It should be noted, however, that although intensity ratios provide useful insights into relative investment and capacity levels across countries, they take into account neither the policy and institutional environment within which agricultural research occurs nor the broader size and structure of a country's agricultural sector and economy (Beintema and Stads 2011a). Based on their contribution to the economy, these countries all have relatively small agricultural sectors. Botswana, Namibia, and Mauritius are all small countries that require higher levels of investment and staffing because they are unable to benefit from the economies of scale available to larger countries. The intensity ratio in Mauritius also reflects its high investment in sugar research. While a large country with a relatively well-funded agricultural research system, South Africa's 2008 intensity ratio was one of its lowest since the 1980s. Hence, levels of investment have not kept pace with AgGDP growth or with the government's 3 percent target.

In contrast to the four countries mentioned above, the investment intensity ratios for Mozambique, Madagascar, Tanzania, and Zambia were all below the SSA average of 0.61 in 2008. Tanzania's 2008 ratio, while still low, had in fact doubled since 2001, which was a positive sign. In Madagascar and Zambia, intensity ratios fell significantly from those recorded in the 1990s due to decreased investment.

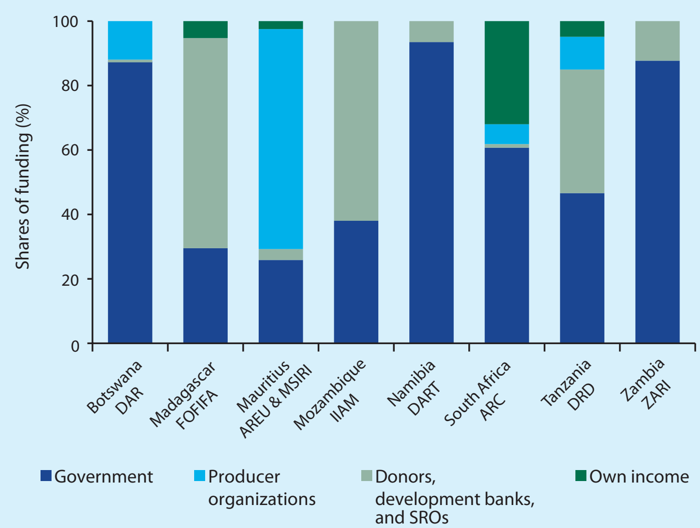
Funding sources. Funding for African agricultural R&D is derived from a variety of sources, including national governments; donors, development banks, Regional Economic Communities (RECs) and subregional organizations (SROs); producer organizations; the private sector; and internally generated revenues.[4] Unsurprisingly, variation is significant across the main agricultural research agencies (Figure 2). Funding sources can also differ substantially across time, so Figure 2 only shows the average distribution for the 2001–08 period. The government funded the bulk of agricultural R&D activities at DAR in Botswana, the Directorate of Agricultural Research and Training (DART) in Namibia, and the Zambia Agriculture Research Institute (ZARI); the government also contributed more than half of ARC's funding in South Africa.

The main agricultural R&D agencies in other countries are more dependent on external funding. Reporting an average share of 65 percent, Madagascar's National Center for Applied Research and Rural Development (FOFIFA) is highly dependent on donor and development bank funding, including technical support from France's Agricultural Research Center for International Development (CIRAD). This share is still high despite a substantial decline in this category of funding in absolute terms since the termination of a large World Bank–loan funded project. Funding for research at the Tanzanian Department of Research and Development (DRD)[5] has traditionally been highly dependent on donors and development banks, but a severe reduction in such funding after 2005 led the government to increase its contributions in efforts to bridge the gap. The sale of goods and services together with contributions through commodity levies also contribute to funding DRD, but this type of funding has also declined over time, reflecting the establishment of dedicated commodity-based research institutions.

In Mozambique, at least half of national funding for agricultural R&D, on average, was derived from donors between 2004 and 2008. Nevertheless, allocations and disbursements became increasingly erratic, so the country's main agricultural research agency, the Agricultural Research Institute of Mozambique (IIAM), became more dependent on government funding during this timeframe, despite decreasing budget allocations from the Ministry of Agriculture.

Commercializing research outputs can be a valuable source of additional income for agricultural research agencies but only in the presence of an enabling policy environment (in many countries, for example, such income is redirected back to the Treasury). Sales of goods and services accounted for a considerable share of agricultural research funding in South Africa, and averaged 15 percent of total funding to ARC during 2004–08. Of the other countries, only agencies in Madagascar, Mauritius, and Tanzania derived funding through the sale of goods and services, but the overall shares were small. Research can also be funded through levies on agricultural production or exports. Commodity levies have been important in funding

Figure 2—Relative shares of funding sources for the main agricultural R&D agencies, average for 2001–08



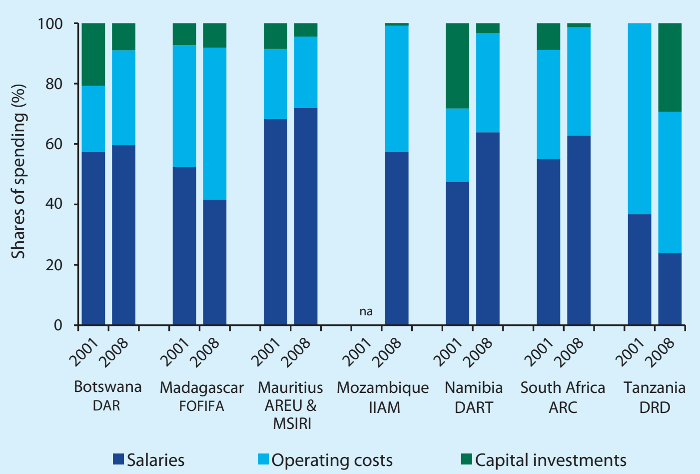
Sources: Compiled by author based on country-level ASTI survey data (see individual ASTI Country Notes).

Notes: SROs indicates subregional organizations; "producer organizations" include contributions through export or production levies; "own income" includes the sale of goods and services and contractual research performed for public and private agencies. Funding shares for some agencies fluctuated over time (see individual ASTI Country Notes). Figure excludes Malawi and Zimbabwe because of data unavailability. The funding distribution for IIAM-Mozambique is for the period 2004–08, and for ARC-South Africa, 2001–07.

research on cash crops such as coffee and tea in Tanzania, sugar in Mauritius, and on a variety of crops in Botswana and South Africa.

Cost-category shares. The allocation of research budgets across salaries, operating costs, and capital investments affects the efficiency of agricultural R&D. In 2008, salaries accounted for more than half of all expenditures at DAR-Botswana (60 percent), IIAM-Mozambique (57 percent), DART-Namibia (64 percent), ARC-South Africa (63 percent), and the Agricultural Research and Extension Unit (AREU) and MSIRI in Mauritius (70 percent); at ZARI-Zambia they accounted for about half of all expenditures.

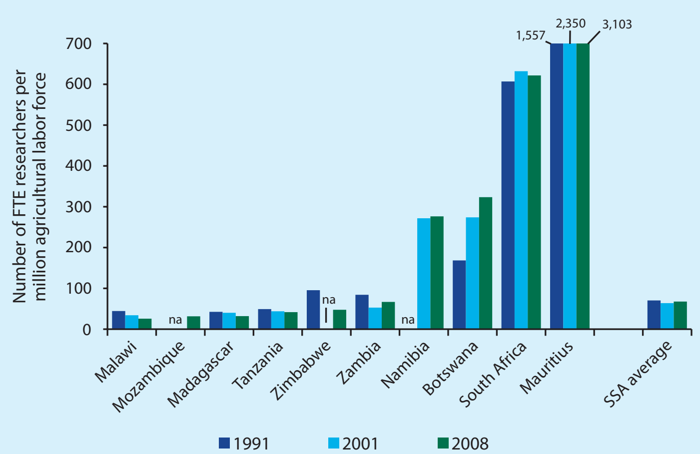
Figure 3—Share of cost categories in total spending of the main agricultural R&D agencies, 2001 and 2008



Sources: Compiled by author based on country-level ASTI survey data (see individual ASTI Country Notes).

Note: Figure excludes Malawi, Zambia, and Zimbabwe because of data unavailability.

Figure 4—Intensity of agricultural researchers by country, 1991, 2001, 2008



Sources: Compiled by author based on country-level ASTI survey data and several secondary resources (see individual ASTI Country Notes). Economically active agricultural population data (here labeled as agricultural labor force) are from FAO 2009.

Note: Intensity ratios were not available for Mozambique for 1991 and 2001; for Namibia for 1991; and for Zimbabwe for 2001.

At South Africa's ARC, the share of capital investments was much lower in 2008 than in 2001 because the council adopted a policy of leasing rather than purchasing equipment and vehicles. Capital expenditures also declined for DAR-Botswana and DART-Namibia. In Botswana, an overall decline in expenditures during 2007–08 caused the share of salaries, which are generally more fixed, to increase. Capital investments were also unusually high in 2001 because of the construction of three regional stations. In Namibia, the share of capital expenditures was much higher during 2001–06 because of donor funding for the rehabilitation of facilities and equipment purchases. At DRD in Tanzania, World Bank project funding enabled stronger capital investments during 2002–04, after which time the government increased its investments and a new World Bank project began in 2007, fueling higher expenditure on salaries, research activities, and equipment and infrastructure. At ZARI in Zambia, capital investments increased in 2008 as a result of rehabilitation efforts after years of underinvestment.

BENCHMARKING KEY HUMAN CAPACITY INDICATORS

Researcher Intensity. Gauging researcher numbers or spending levels against total population or economically active agricultural population facilitates a different kind of comparison across countries. Similar to the pattern of spending intensity previously discussed, Southern Africa's middle-income countries employ higher numbers of researchers in proportion to the agricultural labor force compared with their low-income neighbors. Botswana, Mauritius, Namibia, and South Africa have relatively well-funded research agencies and a comparatively small agricultural labor force. A particularly high ratio in Mauritius (3,103 FTEs) reflects the leading role the country plays in sugarcane research (Figure 4). In 2008, South Africa employed 622 FTE researchers per million of the economically active agricultural population, whereas in Botswana the proportion was 323 FTEs, and in Namibia it was 276 FTEs. In contrast, the remaining countries employed fewer than the SSA average of 70 FTE researchers per million economically active agricultural population in 2008 (ranging from 26 FTEs in Malawi to 67 in Zambia).

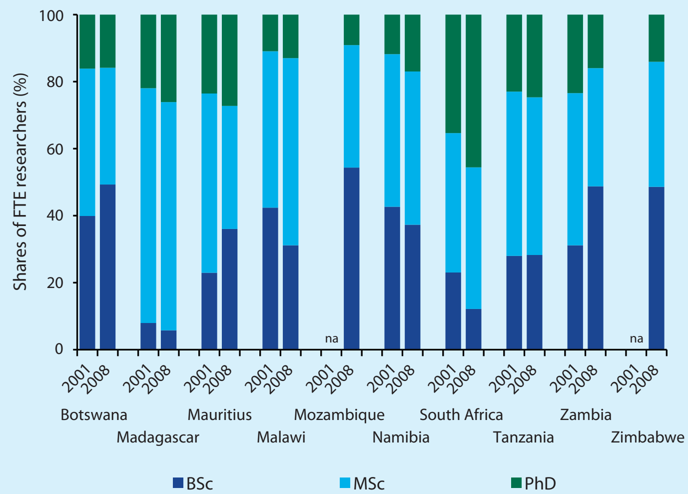
Degree distribution. In 2008, of the SADC countries, South Africa employed the highest share of PhD-qualified research staff (46 percent of all researchers). In absolute terms, however, the number of agricultural researchers in South Africa with higher degrees actually declined across all levels, and the highest decline was among staff qualified to the BSc-degree level only. As a result, South Africa's level of BSc-qualified staff in 2008 was half the level recorded in 2001. Average qualifications improved slightly in Mauritius and Namibia, where the numbers of PhD- and MSc-qualified researchers rose between 2001 and 2008. But despite these improvements, the shares of PhD-qualified researchers in these two countries are still below the SSA average. In Mauritius 13 percent of all researchers held PhD degrees in 2008 and 56 percent held MSc degrees, while in Namibia the comparable shares were 17 and 46 percent, respectively. In comparison, SSA's average shares that year were 30 and 43 percent, respectively.

Zambia underwent the most severe shift in qualification levels during the 2001–08 period. In 2001, 70 percent of researchers were trained to either the MSc or PhD level, but in 2008 this share had fallen to only 50 percent. The retirement of senior researchers, together with losses to other agencies, a government-sector hiring freeze, and a lack of training opportunities all contributed to disproportionate growth in the share of junior researchers qualified to the BSc-level only. Botswana, Mozambique, and Zimbabwe recorded some of the lowest shares of agricultural researchers with postgraduate degrees in SSA. In Botswana, DAR has recruited a large number of young (BSc-qualified) college graduates since 2001. Mozambique's agricultural researchers are also relatively young compared with other countries in the region due to the effects of the civil war. In 2007 for example, half the researchers at IIAM were under 40 years old, 43 percent were between 41 and 50 years old, and only 7 percent were over 50 years old (ASTI–AWARD 2008). In Zimbabwe, both the number and share of BSc-qualified researchers fell significantly from 2003, mainly due to staff losses from inflationary pressures on salaries at the Department of Research and Specialist Services (DR&SS). In general though, DR&SS has very few staff with postgraduate qualifications. In 2008, only 6 percent of researchers held PhD degrees, and only 7 percent held MSc degrees. Training staff should be a primary focus of these four countries in the coming years.

On average, the postgraduate shares of agricultural research staff in Southern African countries are lower than those in many West African countries, which have maintained relatively large pools of well-qualified researchers primarily as a result of training associated with World Bank–funded projects or donor contributions in the 1970s and 1980s. Subsequent lack of funding in these countries has often been accompanied by long periods of restricted recruitment, so many West African countries have a disproportionately older pool of scientists, many of whom are approaching retirement age (Beintema and Stads 2011a). Some Southern African countries are also contending with this problem; Madagascar, for example, has a significant share of senior researchers and recorded the highest share of researchers with PhD and MSc qualifications (94 percent) of all the SADC countries. The average age of FOFIFA researchers was 53 in 2009, and many senior researchers will be due for retirement in the near future. Similarly, in Tanzania most of DRD's researchers are more than 45 years old because of the country's long-term civil service hiring freeze. The Department has recruited many new staff in efforts to address this issue, but most of them are younger and less qualified. For these reasons, these countries will also need to prioritize appropriate training and supervision of their younger researchers.

University-qualified research support. A few SADC countries have significant numbers of BSc- and MSc-qualified support staff (technicians, research assistants, laboratory assistants) who are not officially classified as researchers (Figure 6). In Mauritius, for example, more than one-third of BSc- and MSc-qualified staff at AREU were classified as research support staff in 2008, while at ARC in South Africa, the share was 18 percent. At FOFIFA that year, degree-qualified support staff constituted 12 percent of all university graduates (that is, all researchers and research support staff), while at IIAM they accounted for only 2 percent. In contrast, staff employed at Tanzania's DRD attain researcher status as soon as they complete their BSc degrees.

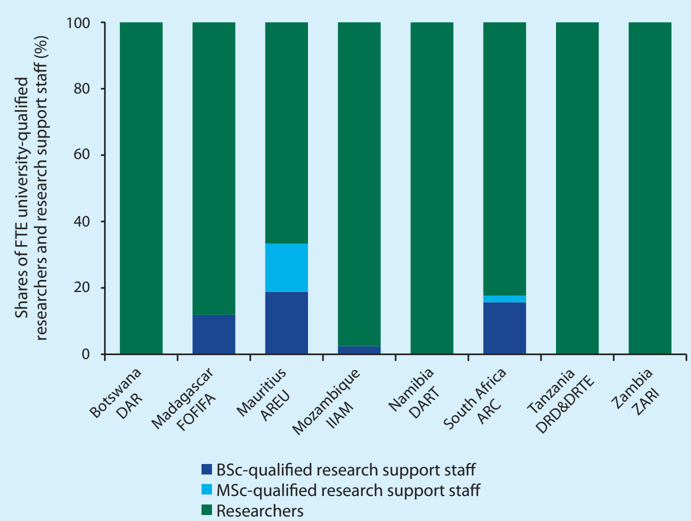
Figure 5—Distribution of agricultural researchers by degree qualification, 2001 and 2008



Sources: Compiled by author based on country-level ASTI survey data (see individual ASTI Country Notes).

Note: 2001 data were not available for Mozambique or Zimbabwe.

Figure 6—University-qualified research support staff as a share of total research staffing, 2008



Sources: Compiled by author based on country-level ASTI survey data (see individual ASTI Country Notes).

Note: Data for Malawi and Zimbabwe were not available.

Female Participation. Female scientists provide valuable insights and perspectives that contribute to solving the unique and pressing challenges facing many African farmers. Yet, although women participate heavily in the agricultural workforce in SSA, they continue to be underrepresented in agricultural research. The overall share of female scientists in the agricultural research system in SSA rose from 18 percent in 2000 to 22 percent in 2008 (Figure 7). Many SADC countries followed this trend, and most of the countries included in this study reported growth in the share of women participating in agricultural research. Overall, most Southern African countries employed relatively more women in agricultural research than the average for SSA as a whole. Only Malawi and Namibia reported lower 2008 shares of female researchers than SSA's regional average. Mauritius and South Africa recorded the highest shares, at about 40 percent of all FTE researchers in 2008. Participation by women increased substantially in Zambia and Botswana to about a quarter and one-third, respectively, of those countries' FTE researchers in 2008. Shares of female researchers also increased by 6 percentage points in Madagascar. In Tanzania, the share of female agricultural researchers has changed little since 2000.

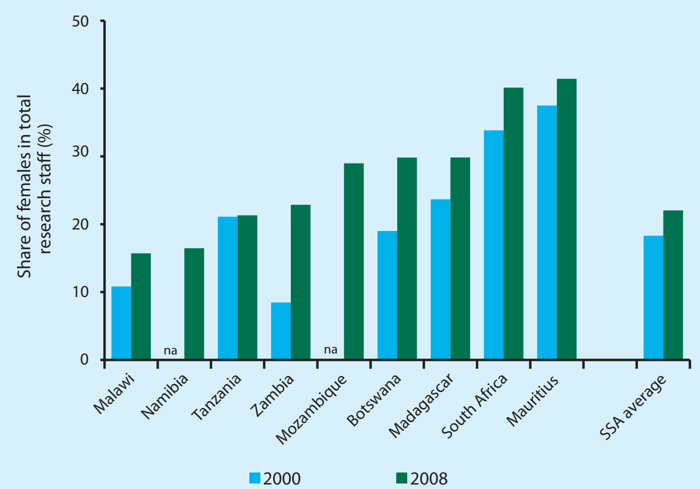
BENCHMARKING OTHER KEY AGRICULTURAL R&D INDICATORS

Institutional distribution. The current structure of agricultural research institutions varies widely by country.[6] In the smaller countries, agricultural research is often undertaken by a handful of government agencies and university faculties. For example, Botswana has 3 government, 1 nonprofit, and 1 higher education agency, while Namibia has 3 government and 3 higher education agencies involved in agricultural R&D. In larger countries with older, more established agricultural research systems, the structures are more complex. South Africa, for example, has 39 agencies involved in agricultural R&D, including 16 federal agencies, 8 provincial departments, 3 nonprofit agencies, and 12 higher education agencies. Madagascar also has a complex system with 8 government, 7 nonprofit, and 5 higher education agencies. Mauritius appears to contradict this general trend with a large number of agencies despite its small population and geographic area, but research activities are led by AREU and MSIRI, and the remaining agencies employ very few researchers.

The institutional composition of national agricultural R&D has gradually shifted over time. Overall, Southern African agricultural research is still dominated by the government sector, but its relative share is declining. One exception is Mauritius, where research capacity at the nonprofit agency MSIRI has been affected by declining sugar prices, and in the higher education sector, researcher numbers declined at the University of Mauritius's Faculty of Agriculture (Figure 8). Notably, government-based agricultural research in Zimbabwe declined from 86 percent in 1991 to 62 percent in 2008. Nonprofit agencies and the higher education sector accounted for a greater share of research in 2008 due to the loss of staff from DR&SS. In Botswana, the higher education sector is playing an increasingly important role, largely because the Botswana College of Agriculture has greatly expanded its research activities since the early 1990s; as of 2008, the college accounted for 27 percent of Botswana's agricultural researchers (in FTEs).

Despite the high and increasing number of higher education agencies conducting agricultural research in Southern African countries, the individual capacity of most of them is small in terms of FTE researcher numbers. Faculty staff spend the great majority of their time teaching, and although the amount of time spent on research has risen over the years, it still represented less than 25 percent on average in 2008.

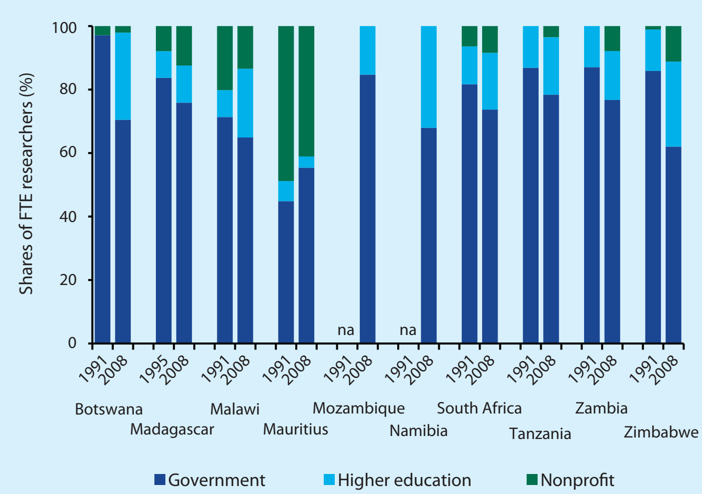
Figure 7—Share of female researchers, 2000 and 2008



Sources: Compiled by author based on country-level ASTI survey data (see individual ASTI Country Notes).

Note: Data for Zimbabwe were not available.

Figure 8—Distribution of agricultural researchers by institutional category, 1991 and 2008



Sources: Compiled by author based on country-level ASTI survey data (see individual ASTI Country Notes).

Note: 2001 data were not available for Mozambique and Namibia.

Agricultural R&D involvement by the nonprofit sector remained relatively small, and varied significantly across the study countries. While nonprofit institutions can have more freedom than publicly funded entities, they are often linked with producer organizations and receive most of their funding via levies on production or exports. MSIRI in Mauritius, for example, is unusually large and reflects the importance of sugar as an export crop. South Africa also has a nonprofit institute that focuses on sugar research, and Tanzania has three such agencies focusing on coffee, tea, and tobacco. Madagascar is one of the few countries in Africa where a number of nongovernmental organizations (NGOs) are involved in agricultural research. Their contribution to Madagascar's research capacity, at 12 percent in 2008, has grown based on increased funding opportunities. The contribution of the nonprofit sector in Zambia has also grown, in this case due to the success of the Golden Agricultural Research Trust (GART) in both attracting donor funding and generating revenue through the sale of goods and services.

Little information could be accessed on capacity or expenditure trends in private agricultural R&D. Most private for-profit companies still outsource their research to government agencies or universities, or they import technologies from abroad. Only a limited number of private companies operate their own research programs, and the companies that do so often employ only a handful of researchers (Beintema and Stads 2006).

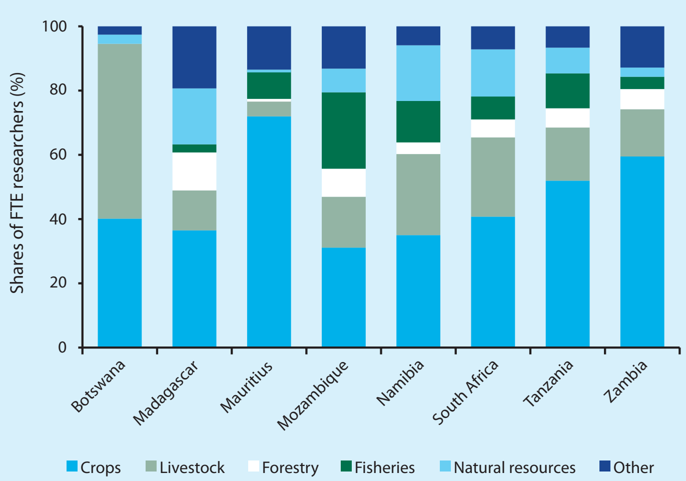
Research allocation by subsector. The allocation of resources among various lines of research is a significant policy decision, so detailed information was collected on the allocation of FTE researchers across specific commodity areas. Large differences were reported across countries, reflecting differences in natural endowments and in research priorities (Figure 9). Crop research accounted for between 52 and 72 percent of the FTE researchers in Mauritius, Tanzania, and Zambia. Half of Botswana's and a quarter of South Africa's and Namibia's FTE researchers focused on livestock. Livestock research ranged between 5 and 17 percent of FTE researchers in all the other countries in the subregion. Fisheries research represented an important part of total agricultural R&D activities in Mozambique, Namibia, and Tanzania (24, 13, and 11 percent, respectively); forestry research in Madagascar and Mozambique (12 and 9 percent, respectively); and natural resources in Madagascar, Namibia, and South Africa (17, 17, and 15 percent, respectively).

Crop research allocation. Predictably, important differences in the focus of crop research were reported across countries (Table 2). Maize and fruit were the most commonly researched crops across the SADC countries. Maize accounted for at least 10 percent of all FTE crop researchers in Mozambique, South Africa, Tanzania, and Zambia. Fruit accounted for 10 percent or more of the FTE researchers in Botswana, Madagascar, Mauritius, South Africa, and Zambia. Sorghum was also an important crop in Botswana (37 percent), Namibia (13 percent), and Zambia (13 percent). Rice was the predominant focus of crop researchers in Madagascar (33 percent), while cassava was the main focus in Mozambique (18 percent). Sugarcane was the main cash crop under research, accounting for 48 percent in Mauritius.

CONCLUDING REMARKS

Total investments in public agricultural R&D in the Southern African countries included in this study increased slightly from the 1990s to 2008. Overall, the 2001–08 investment growth in these countries was lower than average growth

Figure 9—Distribution of agricultural researchers by major sector, 2008



Sources: Compiled by author based on country-level ASTI survey data (see individual ASTI Country Notes).

Note: Figure excludes Malawi and Zimbabwe because of data unavailability.

Table 2—Crop researchers by major crop item, 2008

Country	Major crop items
Botswana	Sorghum (37%), vegetables (14%), fruits (14%), groundnuts (14%), maize (7%), wheat (7%), millet (7%)
Madagascar	Rice (33%), fruits (12%), coffee (9%), maize (8%), vegetables (8%), ornamentals (5%)
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%)
South Africa	Fruits (36%), maize (19%), wheat (13%), potatoes (6%)
Tanzania	Maize (12%), rice (6%), cassava (6%)
Zambia	Maize (19%), sorghum (13%), fruits (11%), cassava (10%), vegetables (9%), groundnuts (5%), soybean (5%)

Sources: Compiled by author based on country-level ASTI survey data (see individual ASTI Country Notes).

Notes: Major crop items are defined as those that form the focus of at least 5 percent of a country's crop researchers. Data for Malawi and Zimbabwe were not available.

in other subregions of the continent. With the exception of Tanzania, public research spending growth stagnated or was negative. However, agricultural research in the middle-income countries of South Africa, Mauritius, Namibia, and Botswana was comparatively well-funded by their national governments. These countries outperformed other subregions, as well as neighboring lower income countries, in many key areas. They are less dependent on donor contributions and development bank loans than are the subregion's low-income countries which have been subject to funding volatility associated with fluctuating allocations and disbursement schedules.

Overall agricultural research staffing in the SADC countries has also grown slightly since the 1990s, but not as much as countries in other subregions of Africa. Corresponding to the high agricultural investment intensity ratios, the middle-income countries have high ratios of agricultural researchers to agricultural laborers. South Africa in particular leads the subregion with its well-established agricultural research agencies and universities. In 2008, South Africa employed the highest share of PhD-qualified research staff among the SADC countries (46 percent).

Strengthening research capacity continues to be a challenge in most of the Southern African countries, and the lack of local PhD programs particularly limits training in Botswana and Namibia. Agricultural researchers in Mozambique, Zambia, Zimbabwe are among the least highly qualified in SSA given that about half are qualified to the BSc level only. Other countries, such as Madagascar and Tanzania, employ an aging pool of researchers as a consequence of long-term government recruitment freezes, so recently recruited staff are young, less qualified, and often have limited training opportunities.

Building on strategic recommendations of various highly influential reports and meetings (IAC 2004, World Bank 2007, IAASTD 2008, Lele et al. 2010) and new evidence collected through ASTI, Beintema and Stads (2011a) outline four key areas that have strong implications for SADC:

- Higher levels of investments are needed ***to counteract decades of underinvestment in agricultural R&D***. Overall investment levels in most SSA countries are still below the levels required for sustaining effective agricultural research agencies, despite the increased commitments of governments, donors, and development banks in recent years in some countries.
- Stable and sustainable levels of government funding are needed ***to halt excessive volatility in yearly investment levels***, caused by a high dependency on unstable donor funding and development bank loans. Governments will need to identify long-term national R&D priorities and design relevant programs while donor funding will need to be better aligned with these priorities.
- Governments and donors need ***to address the existing and imminent challenges in human resource capacity*** to enable agricultural R&D to satisfactorily respond to emerging global challenges. An expansion of investment in agricultural higher education would allow universities to increase the number and size of PhD and MSc programs and to improve the curricula of existing programs.
- National and regional agricultural R&D agencies will need ***to maximize regional and subregional cooperation***. Many small countries in SSA often lack the required critical mass of agricultural capacity and hence face enormous challenges in producing or accessing relevant, high-quality research outputs.

These four key areas will have to be addressed by government, donors, and other stakeholders if African agricultural R&D is to overcome the various investment and capacity challenges it faces to effectively support improved agricultural productivity.

NOTES

[1] ASTI plans to transform the program from an ad hoc program of data collection to a sustainable system of up-to-date data compilation and analysis, including institutionalization of the activities at the national level. This will include a geographical expansion to benchmark countries, such as DR Congo, not previously covered in ASTI survey rounds.

[2] A total of 32 Sub-Saharan African countries were included in the survey round; combined, they contributed more than 90 percent of the region's agricultural gross domestic product (AgGDP).

[3] These trends have been published in a series of ASTI Country Notes, which are listed in the reference section and are available at http://www.asti.cgiar.org/publications/ssa. Underlying datasets can be downloaded via ASTI's Data Tool at http://www.asti.cgiar.org/data.

[4] See Beintema and Stads 2011a and Echeverría and Beintema 2009 for an overview on different funding sources and mechanisms.

[5] All livestock capacity was transferred from DRD in 2001 to form the Department of Research, Training, and Extension (DRTE), but DRTE did not become operationally independent of DRD until 2006.

[6] For agency directories, please see the country pages on the ASTI website at http://www.asti.cgiar.org/countries.

REFERENCES

ASTI (Agricultural Science and Technology Indicators). ASTI website. <http://www.asti.cgiar.org>.

ASTI–AWARD (Agricultural Science and Technology Indicators and African Women in Agricultural Research and Development). 2008. Gender-disaggregated capacity indicators in Sub-Saharan Africa, 2007/08. Unpublished surveys. International Food Policy Research Institute and CGIAR Gender and Diversity Program, Washington, D.C. and Nairobi.

Beintema, N. M., and G. J. Stads. 2006. *Agricultural R&D in Sub-Saharan Africa: An era of stagnation*. ASTI Background Report. Washington, DC: International Food Policy Research Institute.

_________. 2008. *Measuring Agricultural Research Investments: A Revised Global Picture*. ASTI Background Note. Washington, DC: International Food Policy Research Institute.

_________. 2011a. *African Agricultural R&D in the New Millennium: Progress for Some, Challenges for Many*. IFPRI Food Policy Report. Washington, DC: International Food Policy Research Institute.

________. 2011b. *ASTI Toolkit—Monitoring Agricultural R&D Capacity and Investment Indicators: A Practitioner's Guide to ASTI's Methodologies & Data Collection Standards*. Washington, DC: International Food Policy Research Institute. (Forthcoming)

Echeverría, R. G., and N. M. Beintema. 2009. *Mobilizing Financial Resources for Agricultural Research in Developing Countries: Trends and Mechanisms*. Rome: Global Forum on Agricultural Research.

FAO (Food and Agriculture Organization of the United Nations). 2009. FAOSTAT Database. <http://faostat.fao.org/site/452/default.aspx>. Accessed March 23, 2010.

Flaherty, K., and D. Lwezaura. 2010. *Tanzania*. ASTI Country Note. Washington, DC and Dar es Salaam: International Food Policy Research Institute and Department of Research and Development.

Flaherty, K., and M. Mwala. 2010. *Zambia*. ASTI Country Note. Washington, DC: International Food Policy Research Institute.

Flaherty, K., P. Chipunza, and A. Nyamukapa. 2011. *Zimbabwe*. ASTI Country Note. Washington, DC: International Food Policy Research Institute.

Flaherty, K., G. F. Liebenberg, and J. Kirsten. 2010. *South Africa*. ASTI Country Note. Washington, DC and Pretoria: International Food Policy Research Institute, Agricultural Research Council, and University of Pretoria.

Flaherty, K., F. Mazuze, and R. Mahanzule. 2010. *Mozambique*. ASTI Country Note. Washington, DC and Maputo: International Food Policy Research Institute and Agricultural Research Institute of Mozambique.

IAASTD (International Assessment of Agricultural Knowledge, Science and Technology for Development). 2008. *Synthesis Report*. Washington, DC: Island Press.

IAC (InterAcademy Council). 2004. *Realizing the Promise and Potential of African Agriculture: Science and Technology Strategies for Improving Agricultural Productivity and Food Security in Africa*. Amsterdam.

Ipinge, S., M. Rahija, and G. J Stads. 2011. *Namibia*. ASTI Country Note. Washington, DC: International Food Policy Research Institute.

Lele, U., J. Pretty, E. Terry, and E. Trigo. 2010. *Transforming Agricultural Research for Development*. Report prepared for the Global Conference on Agricultural Research for Development, Montpellier, France, March 28–31. Rome: Global Forum on Agricultural Research.

NEPAD (New Partnership for Africa's Development, Office of Science and Technology). 2006. *Africa's Science and Technology Consolidated Plan of Action*. Pretoria.

NEPAD–CAADP (New Partnership for Africa's Development–Comprehensive Africa Agriculture Development Programme). 2010. Pillar 4: Agricultural Research. <http://www.nepad-caadp.net/pillar-4.php>. Accessed November 2010.

Rahija, M., J. Ramkissoon, and G. J. Stads. 2010. *Mauritius*. ASTI Country Note. Washington, DC and Réduit: International Food Policy Research Institute and Food and Agricultural Research Council.

Stads, G. J., and M. Pholo. 2011. *Botswana*. ASTI Country Note. Washington, DC and Gaborone: International Food Policy Research Institute and Department of Agricultural Research.

Stads, G. J., and R. Randriamanamisa. 2010. *Madagascar*. ASTI Country Note. Washington, DC and Antananarivo: International Food Policy Research Institute and National Center of Applied Research and Rural Development.

World Bank. 2007. *World Development Report 2008: Agriculture for Development*. Washington, DC.

________. 2010. *World Development Indicators*. Washington, DC. <http://data.worldbank.org/data-catalog/world-development-indicators/wdi-2010>. Accessed November 2010.

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ASTI compiles, analyzes, and publishes data on institutional developments, investments, and human resources in agricultural R&D in low- and middle-income countries. The ASTI initiative is managed by the International Food Policy Research Institute (IFPRI) and involves collaborative alliances with many national and regional R&D agencies, as well as international institutions. The initiative is widely recognized as the most authoritative source of information on the support for and structure of agricultural R&D worldwide.

IFPRI is one of 15 agricultural research centers that receive their principal funding from governments, private foundations, and international and regional organizations, most of which are members of the Consultative Group on International Agricultural Research (www.cgiar.org).

The Southern African Development Community (SADC) is an inter-governmental organization with 15 member states. Its purpose is to further political, socioeconomic, and security cooperation across Southern Africa.