AGRICULTURAL SCIENCE AND TECHNOLOGY INDICATORS

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SUDAN

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This country brief reviews the major investment and institutional trends in Sudanese agricultural research since the early 1970s, including a new set of survey data for the 1990s collected through the Agricultural Science and Technology Indicators (ASTI) initiative (IFPRI–ISNAR–ASARECA 2002–03).[1]

INSTITUTIONAL DEVELOPMENTS

As in many developing and other African countries, agriculture is the foundation of Sudan's economy. It accounts for 41 percent of gross domestic product (GDP) and 61 percent of total employment (FAO 2003; World Bank 2003). After petroleum, which represented 75 percent of the country's total export value in 2000, agricultural products are Sudan's main export commodities. Primary among these are cotton, sesame seed, and sheep, which accounted for more than half the nonpetroleum export revenues in 2000 (Salih 2003).

Sudan's total cereals production is usually sufficient to fulfill domestic needs, especially in terms of sorghum and millet, but Sudan is a net importer of wheat. The country even has the potential to become the main food provider for Africa and the

Table 1—Composition of agricultural research expenditures and total researchers, 2000

Type of agency	Spending: 1999 Sudanese dinnars (millions)	Spending: 1993 international dollars (millions)	Researchers[a] (fte's)	Share: Spending (percent)	Share: Researchers (percent)	Agencies in sample[b] (number)
Public agencies						
ARC	872.0	16.5	358.0	41.8	45.3	1
ARRC[c, d]	351.5	6.7	144.3	16.9	18.2	1
Other government[c, e]	137.2	2.6	52.6	6.6	6.7	2
Higher education[c, e, f]	551.0	10.4	224.8	26.4	28.4	27
Subtotal	*1,911.7*	*36.2*	*779.7*	*91.7*	*98.6*	*31*
Business enterprises	172.0	3.3	11.0	8.3	1.4	1
Total	**2,083.6**	**39.5**	**790.7**	**100**	**100**	**32**

Sources: Compiled by authors from ASTI survey data (IFPRI –ISNAR–ASARECA 2002–03), Ageeb et al. (1999), Awad (2003), and KSC (2003a).

[a] Include national and expatriate staff.

[b] See note 2 for details of all agencies. The Faculty of Veterinary Medicine of the University of Nyala, Southern Kordofan's Faculty of Agriculture, and the College of Forestry and Range Science of the Sudan University of Science and Technology were excluded from this table and further data analysis in this brief because data were unavailable.

[c] The 220 professional staff employed at ARRC spent an estimated 65 percent of their time on research, resulting in 156 fte researchers.

[d] Expenditures for ARRC, other government agencies, the higher-education sector, and business enterprises in our sample are estimates based on the ARC's average expenditures per researcher.

[e] Fte researcher data for HRS and three of the smaller higher-education agencies were estimated using 1997 data from Ageeb et al. (1999).

[f] The 1,068 faculty staff employed in the 27 higher-education agencies spent between 10 and 65 percent of their time on research, resulting in 224.8 fte researchers.

KEY TRENDS

- Agricultural research investments in Sudan, in real prices (adjusted for inflation), decreased over the past three decades because of declining government contributions and waning donor funding.
- Total agricultural research staff numbers have increased considerably in the 1990s, but the share of researchers holding doctorate degrees declined.
- The Agricultural Research Corporation (ARC) and the Animal Resource Research Corporation (ARRC) are the main agricultural research agencies in Sudan; together they accounted for about 60 percent of the country's total agricultural research spending and staff numbers in 2000.
- Higher-education agencies accounted for more than a quarter of total resources, but a large number of agencies have only a small research capacity.
- Private-sector investments in agricultural research are limited in Sudan and are mostly focused on sugarcane.

ABOUT ASTI

The Agricultural Science and Technology Indicators (ASTI) Initiative consists of a network of national, regional, and international agricultural R&D agencies managed by IFPRI and ISNAR. The initiative compiles, processes, and makes available internationally comparable data on institutional developments and investments in public and private agricultural R&D worldwide, and analyses and reports on these trends in the form of occasional policy digests for research policy formulation and priority setting purposes.

Primary funding for the ASTI initiative was provided by the CGIAR Finance Committee/World Bank with additional support from the Australian Center for International Agricultural Research (ACIAR), the European Union, and the U.S. Agency for International Development (USAID).

Middle East. But variability of rain, seasons of severe drought, problems with food distribution, and civil war—among other reasons—have left the country with recurring food shortages over the past few decades. Strengthening agricultural research and development (R&D) is an important component of the strategy to reverse the trend of increasing food insecurity and poverty in Sudan (Salih 2003a).

We identified 35 agencies engaged in agricultural research in Sudan in the late-1990s, 32 of which are included in our sample.[2, 3] These 32 agencies employed close to 800 full-time equivalent (fte) researchers and spent more than 2 billion 1999 Sudanese dinars on agricultural R&D—equivalent to about 40 million 1993 international dollars (Table 1).[4] The Agricultural Research Corporation (ARC) and the Animal Resource Research Corporation (ARRC) are Sudan's principal agricultural research agencies. In 2000 ARC accounted for more than 40 percent of both the country's total agricultural research spending and public-sector research staff.

Until recently, ARC's management was supported by a board of directors, responsible to the Ministry of Agriculture and Forestry, and consisting of ARC's director general and representatives of concerned ministries, universities, farmer groups, as well as other agricultural research institutions and interest groups. The board was entrusted with developing ARC's research policy, seeking funding, approving budgets, strengthening research programs, and appointing senior management staff (Salih 2002). In 2001, ARC as well as ARRC, NRC (National Research Center), and other research institutions in the country became part of a newly established ministry; the Ministry of Science and Technology (MOST).[5] Also as part of the reorganization, the government dissolved all administrative boards, leaving MOST with full administrative responsibility for ARC as well as for ARRC and NRC. It is anticipated, however, that the boards will be reinstated in the near future.

ARC is headquartered in Wad Medani but recently some of its operations were moved to Shambat in Khartoum State. Its activities are organized into 24 research programs covering research on crops and forestry, along with cross-cutting disciplinary research on agricultural engineering, biotechnology, crop protection, food processing, genetic resources, socioeconomics, soils, and water (ARC 2002). Part of those activities are administered within four research centers—the Food Research Centre, the Forestry Research Centre, the Land and Water Research Centre, and the Crop Protection Research Centre—along with 18 research stations that are distributed across the country. Historically the Gezira Research Station, one of ARC's oldest and most important research stations, has housed the largest share of researchers, at around one-third of the total. This includes staff associated with the Land and Water and Crop Protection Research Centres, which were located within the research station. The balance of ARC researchers is disproportionately distributed over the remaining 17 research stations (Ageeb et al. 1999; Salih 2002). ARC's institutional structure, however, has changed little in the past 35 years and needs updating to better reflect the many changes that have occurred over that time. New centers and research resources are needed in the areas of natural resources, biotechnology, and rain-fed agriculture, while research in the southern part of the country needs strengthening (Salih 2002).

ARRC was established in 1995 with the centralization of public animal research activities through mergers of existing research agencies (see *A Short History of Government-Based Agricultural Research below*). ARRC also reports to MOST. The corporation consists of the Central Veterinary Research Laboratories Centre, the Animal Production Research Centre, the Fisheries Research Centre, the Wildlife Research Centre, and a network of 26 regional veterinary laboratories and animal production research stations (MOST 2003). Currently, vaccines to treat 12 of the major livestock epidemics are locally produced within ARRC's veterinary laboratories. ARRC is estimated to have accounted for close to 20 percent of Sudan's total public agricultural research spending and staff in 2000.[6]

Two other government agencies—the Hydrology Research Station (HRS) and NRC—engage in agricultural research activities, accounting for a combined 7 percent of Sudan's total public research capacity in 2000. HRS investigates conveyance

A Short History of Government-Based Agricultural Research

Agricultural research in Sudan began under British rule in attempts to launch cotton production for the international market. Experimental research on irrigated cotton began in the northern part of the country in 1902, and quickly expanded to other regions. Chemical and entomological research related to agriculture started in 1903 with the establishment of the Welcome Tropical Research Laboratories (focusing mainly on medical research) and in 1904 with the Shambat Agricultural Experiment Station. The successful results of pilot schemes and experiments by the Sudan Plantation Syndicate on commercial-scale cotton growing in Gezira prompted the establishment of the Gezira Research Station by the Department of Agriculture in 1918. The Department of Agriculture or the Department of Education administered the research stations until the Agricultural Research Service (ARS) was formed as an autonomous body in 1931 to consolidate research undertaken to serve the Gezira Scheme. After World War II, food security goals directed attention away from cotton and toward food crops and work on mechanized grain production in the rainfed areas. Two research stations were established to improve production of field and horticultural crops in the south.

Local veterinary diagnostic services were first made available in 1913 when the Central Veterinary Research Administration (CVRA) was established to control outbreaks of serious animal diseases. In 1953 and 1955 fisheries and animal production research were initiated with the establishment of the Fisheries and Marine Biology Center (FMBC) and the Animal Production Administration (APRA), respectively.

After independence in 1956, agricultural research expanded rapidly to encompass a variety of crops across several ecological zones in response to issues of food security and declining international cotton prices. To strengthen the institutional setting for research, the government upgraded the Agricultural Research Division (ARS) in 1967, renaming it the Agricultural Research Corporation (ARC) and giving it semi-autonomous status and responsibility for virtually all applied agricultural research on field crops. In 1975 a number of other institutes—FMBC, the Forest Research Centre, and the Food Research Center—were merged with ARC, broadening its mandate. In 1996, however, fisheries and marine life and wildlife research were transferred from ARC to the newly established Animal Resource Research Corporation, which also took over from CVRA and APRA.

Sources: Beintema et al. (1995); Ageeb et al. (1999); and Salih (2002).

systems of irrigation water along with issues of weed control and siltation in irrigation canals of the Gezira Scheme (Ageeb et al. 1999).[7] Four units within the NRC conduct agricultural research: the Environment and Natural Resources Research Institute, the Medicinal and Aromatic Plants Research Institute, the Biotechnology and Genetic Engineering Corporation, and the Arid and Dry Lands Research Institute.

We identified 30 higher-education agencies, 27 of which accounted together for over a quarter of the total number of research staff in 2000. Only two higher-education agencies—the University of Khartoum's Faculty of Agriculture and the Faculty Veterinary Medicine—employed more than 30 fte researchers in 2000, while 20 of the 27 agencies employed fewer than 10 fte researchers, and 13 agencies employed fewer than 5. Many higher-education agencies were only established within the past 15 years with the expansion of the higher-education sector and the associated spread of institutions across the country in response to the federal reorganization of Sudan in 1995 as 26, rather than 9, states.

We identified only one private company in Sudan, which was responsible for the majority of agricultural research activities on sugarcane in Sudan. The Kenana Sugarcane Company (KSC) employed 11 fte researchers in 2000. It conducts applied research to promote and maintain high yields and to reduce production costs (KSC 2003b). The Sudan Sugar Company (SSC), a nonprofit institution, also conducts sugarcane research at Guneid station, but on a much smaller scale. The Guneid station was part of ARC until 1997, when it was relocated due to better funding and employment opportunities under SCC.

Sudan does not have a central coordinating body for agricultural research, but linkages do exist between ARC, ARRC, and other government and higher-education agencies. Permanent technical committees within ARC (the Variety Release, Crop Husbandry, and Pests and Diseases Committees) and various ad hoc ARRC committees are responsible for releasing research recommendations in their respective disciplines based on presentations and discussions of research findings, which allow stakeholders to table their interests for incorporation in research programs. There is also an ARC technical committee that looks into and approves research programs and projects, although (like the boards that in the past provided another entry point for feedback) this committee is currently inactive.

Over time, ARC has developed collaborative R&D links with a variety of institutions within and outside Sudan. Domestic links exist with many ministries and institutions both in terms of stakeholders and donors. Agricultural links have been established with faculties throughout the country in terms of teaching, postgraduate supervision, and joint research projects. External cooperation involves many centers of the Consultative Group on International Agricultural Research (CGIAR) [8] and other international organizations such as the International Centre for Insect Physiology and Ecology (ICIPE), the International Centre for Biosaline Agriculture (ICBA), and the World Association of Industrial and Technological Research Organization (WAITRO).

ARC also collaborates with regional organizations like the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA), the Association of Agricultural Research Institutions in the Near East and North Africa (AARINENA), and the Arab Centre for the studies of Arid Zones and Dry Lands (ACSAD). These regional links involve collaborative research programs and the provision of small research grants, technical training, germplasm, and technical assistance (Salih 2003b). ARC also collaborates with a network of international universities, including several in Germany, the Tottori University in Japan, and the University of Helsinki in Finland, which have sponsored visits by ARC researchers to their facilities.

Through ARRC linkages, Sudan is a member country in the Office of International Epizootics (OIE). ARRC has also links to ASACRECA, while through its camel research program the corporation collaborates with ACSAD.

HUMAN AND FINANCIAL RESOURCES IN PUBLIC AGRICULTURAL R&D

Overall Trends

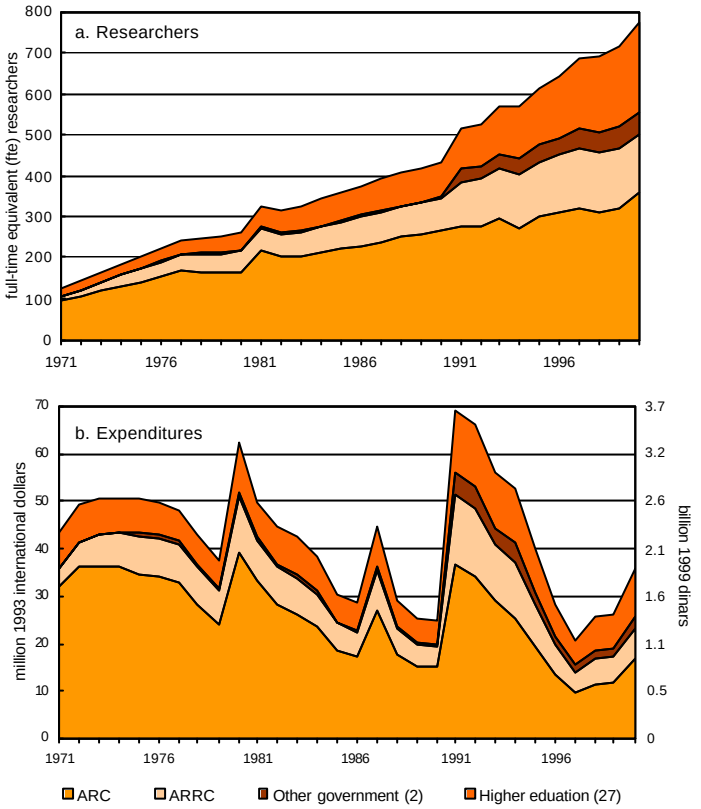
Over the past three decades, the total number of agricultural research staff in Sudan grew considerably, averaging close to 6 percent per year (Figure 1a).[9] During the 1990s the growth in total researcher numbers at the government agencies slowed to 3 percent per year. In contrast, the total number of fte researchers employed at the higher-education agencies more than doubled, from 99 in 1991 to 225 in 2000, as the result of the establishment of many new universities during this period.

Until independence in 1956 most of Sudan's agricultural research was conducted by expatriate staff, but after independence the share of expatriate researchers quickly declined to become negligible by the mid-1970s (Beintema et al. 1995). In 2000, Sudan employed only three fte expatriate researchers.

In contrast, total agricultural R&D spending declined at an average rate of 2 percent per year over the past three decades. After a few years of growth, total spending fell by two-thirds, from $50 million in the mid-1970s to less than $30 million in the mid-1990s (Figure 1b). This resulted from declining (and instable) government contributions to agricultural research affecting both the government and higher-education agencies. Total spending recovered somewhat in the late 1990s to reach $37 million by 2000. This seemingly occurred after the Ministry of Finance raised the priority of agricultural research (Salih 2003b).

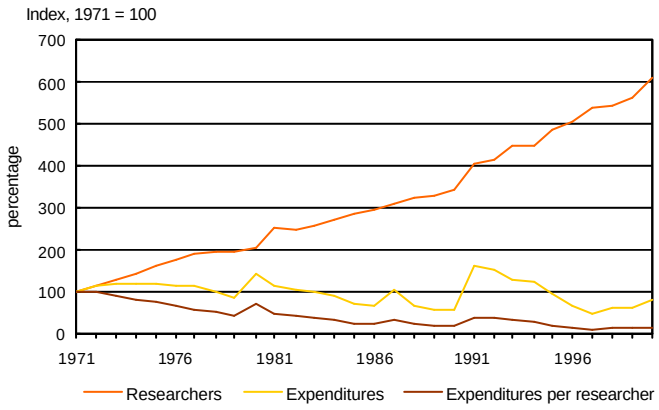
Agricultural researchers in Sudan were well resourced in the 1970s, but as total spending declined and total research staff numbers grew, spending per scientist fell to very low levels. In the 1970s, total spending per scientist averaged $237,000 (Figure 2). By 2000, researcher spending averaged $46,000—half the average level in the East and Central African region that year (Beintema 2003).[10]

Figure 1¾ Public agricultural R&D trends, 1971-2000



Sources: Compiled by authors from ASTI survey data (IFPRI –ISNAR–ASARECA 2002–03), Ageeb et al. (1999), Awad (2003), and Beintema et al (1995).
Notes: See Table 1. Figures in parentheses indicate the number of agencies in each category. Underlying data are available at the ASTI website (www.asti.cgiar.org).

Figure 2¾ Long-term public agricultural R&D trends, 1971–2000

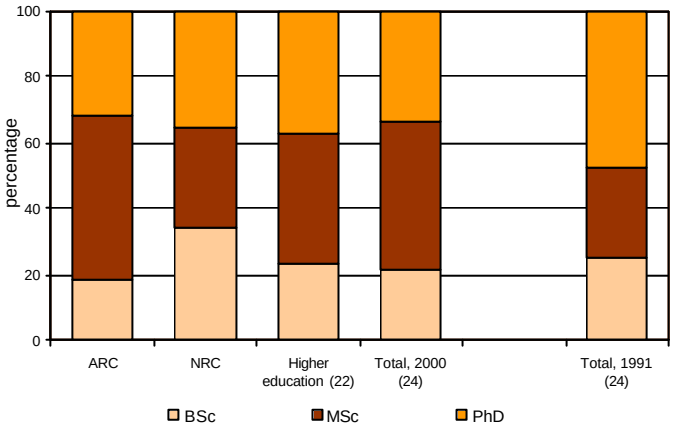


Source: Figure 1.

Human Resources

In 2000, 79 percent of the 591 fte researchers in a 24-agency sample had postgraduate-level training, and one-third held doctorate degrees (Figure 3). The doctorate-level share is high relative to the East and Central African regional average of 22 percent that year (Beintema 2003). ARC employed comparatively more researchers with postgraduate degrees (82 percent), while NRC employed more with BSc degrees. The quality of staff at the government agencies—measured in terms of the share of researchers with PhD and MSc degrees—increased slightly, from 75 percent in 1991 to 79 percent in 2000. The share of ARC researchers with doctorate degrees declined noticeably, from 48 percent in 1991 to 32 percent in 2000. Possible explanations are the high number of—often more senior—researchers departing for better paid positions at regional and international organizations or agencies in other Arab countries (Ageeb et al. 1999; Salih 2002), senior researchers retiring, and reductions in postgraduate training due to dwindling funding. The higher-education sector also experienced a relative decline in the number of researchers with doctorate degrees, from 55 percent in 1991 to 37 percent in 2000. This is likely the result of the disproportionate recruitment of researchers with BSc and MSc degrees when the new education agencies were established.

Figure 3¾ Educational attainment of researchers, 2000

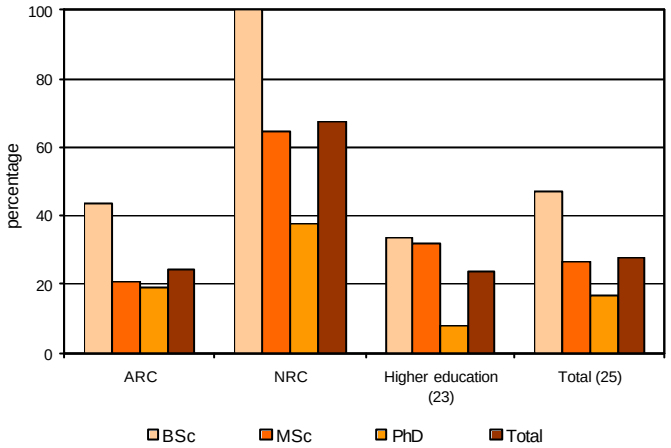


Source: Compiled by authors from ASTI survey data (IFPRI–ISNAR–ASARECA 2002–03) and Beintema et al. (1995).
Note: Number of agencies in sample shown in brackets. Figure excludes expatriate staff.

Currently most MSc and PhD training occurs locally. ARC predominantly hires BSc-level research assistants and then supports their higher educational training. External training is limited to foreign scholarships sought independently by researchers. Many local universities accept postgraduate-level ARC and ARRC staff as students. Most of these students are enrolled at the University of Khartoum, Gezira University, the Sudan University of Science and Technology, Juba University, and the Islamic University of Umdurman.

In 2000, 28 percent of the total fte researchers in a 25-agency sample were female, including 17 percent of all researchers holding doctorate degrees and 26 percent of all researchers trained to the MSc level (Figure 4). This represents more than a 50 percent increase in the female share of research staff in the 1990s, from 12 percent in 1991 (Beintema et al. 1995).

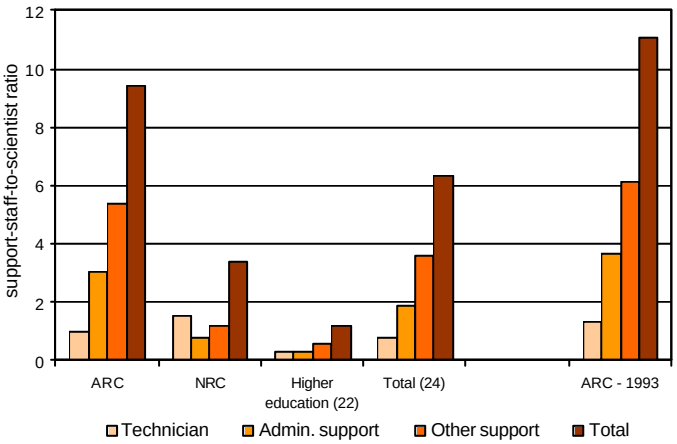
Figure 4¾ Share of female researchers, 2000



Source: Compiled by authors from ASTI survey data (IFPRI–ISNAR–ASARECA 2002–03).
Note: Number of agencies in sample shown in brackets. Figure excludes expatriate staff.

In 2000, the average number of support staff per scientist for a 24-agency sample was 6.3, comprising 0.8 technical staff, 1.9 administrative personnel, and 3.6 other support staff such as laborers, guards, drivers, and so on (Figure 5). The support-staff-per-scientist ratio was lower at the higher-education agencies, at 1.2. The 2000 ratio of 9.4 for ARC was slightly lower than the corresponding ratio of 11.1 in 1993, which is the result of the disproportionate increase in research staff compared with support staff in recent years.

Figure 5¾ Support-staff-to-researcher ratios, 1993 and 2000

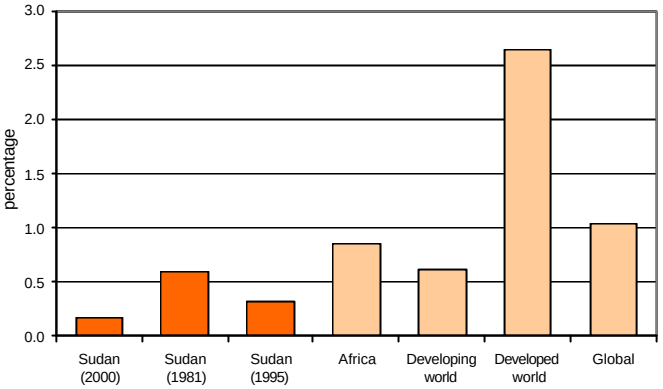


Source: Compiled by authors from ASTI survey data (IFPRI–ISNAR–ASARECA 2002–03).
Note: Number of agencies in sample shown in brackets. Figure excludes expatriate staff.

Spending

Total public spending as a percentage of agricultural output (AgGDP) is a common research investment indicator that helps to place a country's agricultural R&D spending in an internationally comparable context. In 2000, Sudan invested $0.17 for every $100 of agricultural output (Figure 6). Sudan's ratio declined over time, considerably lowering its ranking among other countries in the region. The 2000 intensity ratio was less than half of the 1981 and 1995 levels, even though the 1995 level of 0.33 percent was already very low compared with averages for Africa and the developing world at the time (0.84 and 0.62 percent, respectively).

Figure 6¾ Sudan's public agricultural research intensity compared regionally and globally

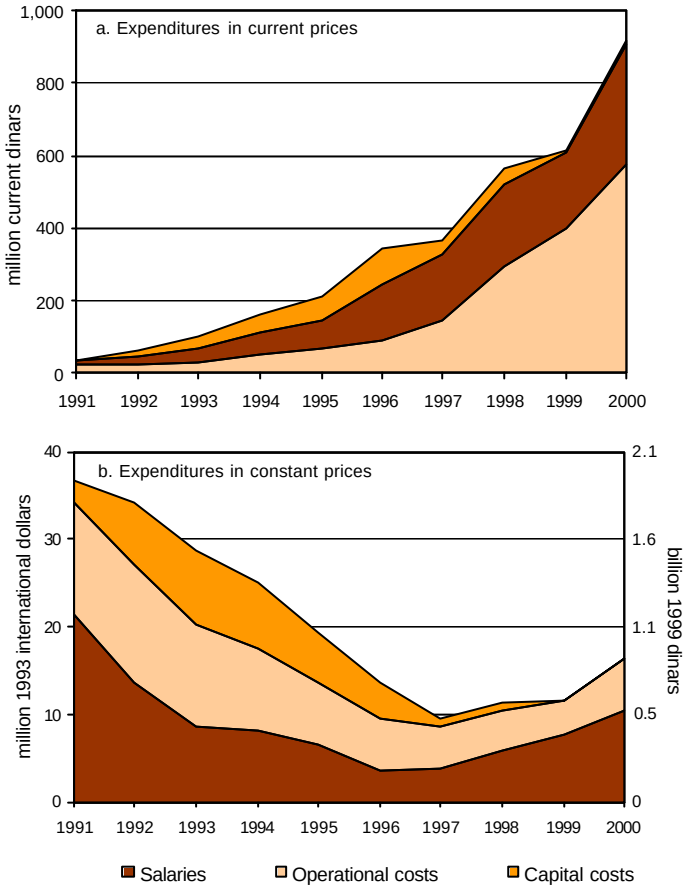


Sources: Sudan compiled from Figure 1b; AgGDP from World Bank (2003); other intensity ratios from Pardey and Beintema (2001).

Although ARC's spending in current prices increased in the 1990s (Figure 7a), in real terms it rapidly declined given the very high inflation rates in Sudan over this period (Figure 7b). The slight recovery in ARC spending in the late 1990s stemmed from the fall of inflation rates and the aforementioned increase in government support to ARC.

On average, salaries accounted for 43 percent of total spending, while operational and capital costs averaged 38 and 18 percent, respectively, during the 1990s. As a result of diminishing donor contributions, ARC made virtually no capital investments in recent years. In 2000, capital costs represented only a 1 percent share of total spending compared with about 30 percent in the mid-1990s. Despite this, many advances were made over this period including the establishment of new research stations, such as the Dongola and Merawi stations in northern Sudan, procurements of field and laboratory equipment, and purchase of transport facilities. Government allocations for operational and capital expenditure were highly variable during the 1990s, but in the late 1990s became severely limited (Ageeb et al. 1999). As a result, ARC physical infrastructure has deteriorated and became outdated (Salih 2002).

Figure 7¾ Cost-category shares in ARC's expenditures, 1991–2000



Source: Compiled by authors from ASTI survey data (IFPRI–ISNAR–ASARECA 2002–03).
Notes: Data include estimated salaries for expatriate staff (see Methodology on page 9).

FINANCING PUBLIC AGRICULTURAL R&D

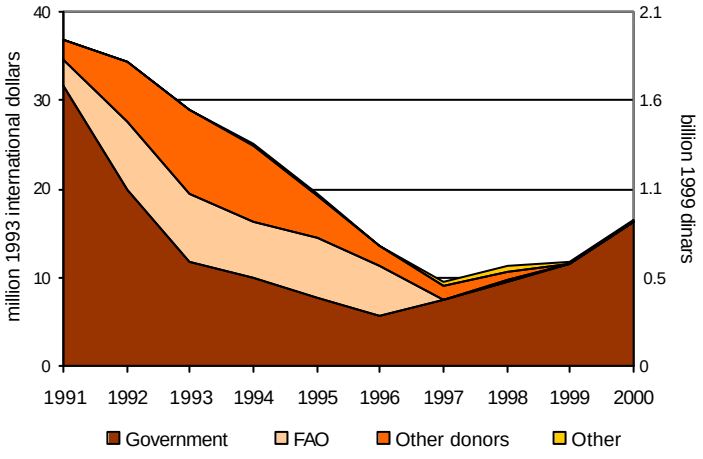
Funding for agricultural research in Sudan depends on government and external donor contributions, which declined significantly between 1991 and 2000 (Figure 8). Government contributions to ARC, adjusted for inflation, declined from $32 million in 1991 (of a $37 million in total funding resources), to $6 million by 1996, and then rebounded somewhat to $16 million by 2000.[11] In addition, large discrepancies occur between budgeted and actual disbursements of the government contributions to ARC and other government agencies. During the second half of the 1990s actual funding to ARC was in the range of around 50 to 70 percent of approved budget allocations, but dropped sharply as from 2001 to only about 30 percent.

The United Nations Food and Agricultural Organization (FAO) was the major agency channeling ARC's funding from donors during 1991–96, accounting for 8 to 42 percent of ARC's total funding. This support was mainly associated with two major research ventures, the Fertilizer Verification Program and the Integrated Pest Management (IPM) Project. Both programs focused on the Gezira Scheme, extending from the early 1980s into the mid-1990s. The fertilizer program was funded by the European Union through FAO to tailor fertilizer application amounts to soil fertility levels, which depict considerable spatial variability. The IPM project was funded by the Government of the Netherlands, also through FAO, to explore natural enemies, agronomic practices, and plant breeding as defenses against insect pests in cotton and rotational crops. The US$7.3 million project consisted of four phases and ran until 1997. The first three phases were mostly devoted to cotton, while the last phase focused mostly on vegetables but also on cotton and wheat. Since 1997, funding through FAO has fallen to less than one percent of ARC's yearly funding, mainly because activities introduced under these two programs have been concluded.

The Agricultural Research, Training, and Extension Project (ARTEP), funded by a World Bank loan, provided major support to ARC's infrastructure development, along with training opportunities. Of the US$30 million World Bank loan, about 80 percent went to ARC. The remainder went to universities—mainly to the Gezira University for the project's training component—and to the National Extension administration to strengthen extension services. ARC's share supported the establishment and rehabilitation of six research stations serving Sudan's irrigated areas (Gezira, Sennar, Soba, Rahad, New Halfa and Shendi). Specifically, this included the purchase of vehicles, the construction of houses and offices, and the purchase of field and laboratory equipment. ARTEP also provided overseas MSc and short-term training for many researchers. Difficulties arose, however, partly because of high inflation and poor exchange rates, which caused construction delays. The project concluded in the second half of the 1990s.

ARC also received substantial funding from other donors such as the Government of Italy, the International Fund for Agricultural Development (IFAD), and the Government of the Netherlands (as already mentioned). Most of the funding from these sources was associated with ICARDA's Nile Valley and Red Sea Regional Program (NVRSRD) on cool-season food legumes and cereals, which also involved Egypt, Ethiopia, and Yemen.[12] Funding was also received through joint projects with ASARECA, and from SCC, mainly for cotton research. In addition, three irrigated production endeavors—the Gezira Scheme, the Rahad Production Corporation, and the New Halfa Production Corporation—provided in-kind support in the form of fertilizers, pesticides, and gasoline.

Figure 8¾ ARC funding sources, 1991–2000



Source: Compiled by authors from ASTI survey data (IFPRI –ISNAR–ASARECA 2002–03).

Self-generated revenues by ARC have been limited and variable to date, but efforts are continuing in this direction. Such revenues are raised by utilizing part of the unused research fields in commercial production of some crops as well as sales of products of research and services, and help in supplementing operational and research budgets.

Research funding at the higher-education institutions in Sudan comes from a variety of sources, but also faces significant limitations. The Ministry of Higher Education and Scientific Research is responsible for allocating a portion of its budget to research activities at the higher-education agencies, but, in practice, these funds have been meager and insufficient to support research activities (Abdalla 2003). In recent years, some funding has been generated through fees paid by students enrolled within a private acceptance system. [13] Some university faculties also provide limited grants to postgraduate students, but the students' employers usually fund such activities, or students raise their own funding. Some foreign donors occasionally provide research grants to universities or through bilateral cooperation (for example through the Ford Foundation, the German Academic Exchange Service (DAAD), or various foreign universities). However, these sources have dried out during the 1990s—the only probable continuing source at present is DAAD. Staff members can also seek funding independently for their own projects.

PRIVATE AGRICULTURAL R&D

Agricultural R&D performed by the private sector in Sudan is extremely limited. We identified only one private company, KSC, which accounted for 8 percent of the total agricultural R&D investments and 1 percent of total fte researchers employed in 2000. Not surprisingly, this reflects a very high investment level per researcher compared with the average in the public sector. KSC research was initiated in 1974, prior to the initiation of commercial sugar production in Sudan (which occurred in 1980–81). From its outset, KSC's research program pioneered many aspects of sugarcane research and since 1981, its activities have been well coordinated with ARC. KSC's Sugarcane Research Department attends ARC's National Technical Committees and participates in ARC's in-house meetings about research findings, programs, and the release of these findings. KSC's research is also linked with world-renowned sugar research facilities in France, the West Indies, India, and the United States. These collaborations primary aim to increase the sugarcane gene pool and to adopt and adapt advanced research and development techniques (KSC 2003b).

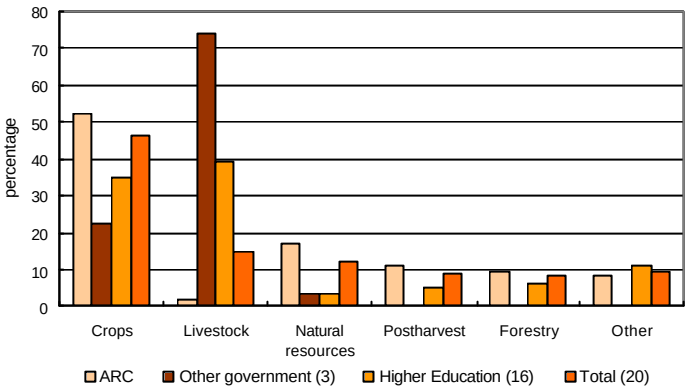
RESEARCH ORIENTATION

Commodity Focus

The allocation of resources across various lines of research is a significant policy decision; hence detailed survey information was collected on the number of fte-researchers working in specific commodity areas.

In 2000, 46 percent of the 540 fte researchers in our 20-agency sample conducted crop research (Figure 9). Livestock, natural resources, and postharvest research accounted for 14, 12, and 9 percent of researchers, respectively, while 8 percent of fte researchers focused on forestry research. ARC researchers spent relatively less time on livestock research (2 percent), which is unsurprising since ARRC is given responsibility for livestock research in Sudan (Figure 10). The researchers at the 16 higher-education agencies, combined, spent considerably more time on livestock research than the sample average (40 percent). The major crops under research at ARC were cotton and vegetables; accounting for 10 and 9 percent of the total fte crop researchers in 2000 (Figure 10). Researchers working on wheat, fruits, gum Arabic tree, and sorghum accounted for 4 to 6 percent each. A large proportion of ARC research activities could not be allocated to specific crops because a major part of the work is conducted on cross-cutting activities such as plant protection, soil, water, and food research, all relevant to more than one crop.

Figure 9¾ Commodity focus of FTE researcher by major item, 2000



Sources: Compiled by authors from ASTI survey data (IFPRI–ISNAR–ASARECA 2002–03).
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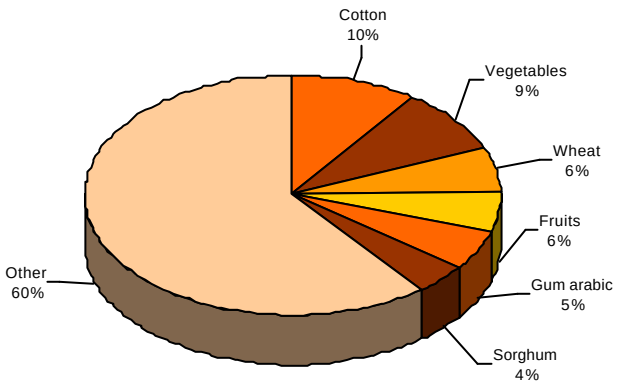
Figure 10¾ ARC crop research by major items, 2000



Sources: Compiled by authors from ASTI survey data (IFPRI–ISNAR–ASARECA 2002–03).

CONCLUSION

Strengthening Sudan's agricultural research system is a key component in addressing the country's increasing food insecurity and poverty. Nevertheless, public agricultural R&D spending has decreased over the past 30 years because of declining (and instable) government contributions to agricultural research combined with the completion of two FAO-executed projects, a third project, ARTEP, funded through a World Bank loan, and discontinuation of funding related in cooperation with ICARDA. Moreover, actual government funding to agricultural research has fallen far short of approved budget allocations.

Notwithstanding, Sudan's total number of agricultural researchers has increased during the past three decades, but this was mainly the result of the creation of new universities with agricultural science faculties. Despite the increasing numbers, the quality of staff in terms of postgraduate qualifications has deteriorated.

Like other countries in the region, and developing countries in general, whose economies depend on the agriculture sector, recognition of the importance of agricultural R&D and the inherent need for adequate and stable R&D funding is vital.

METHODOLOGY

- Most of the data in this brief are taken from unpublished surveys (IFPRI, ISNAR, and ASARECA 2001-02).
- The data were compiled using internationally accepted statistical procedures and definitions developed by the OECD and UNESCO for compiling R&D statistics (OECD 1994; UNESCO 1984). We grouped estimates using three major institutional categories—government agencies, higher-education agencies, and business enterprises, the latter comprising the subcategories private enterprises and nonprofit institutions. We defined public agricultural research to include government agencies, higher-education agencies, and nonprofit institutions, thereby excluding private enterprises. Private research includes research performed by private-for-profit enterprises developing pre, on, and postfarm technologies related to agriculture.
- Agricultural research includes crops, livestock, forestry, and fisheries research plus agriculturally related natural resources research, all measured on a performer basis.
- Financial data were converted to 1993 international dollars by deflating current local currency units with a Sudanese GDP deflator of base year 1993 and then converting to U.S. dollars with a 1993 purchasing power parity (ppp) index, both taken from World Bank (2003). Ppp's are synthetic exchange rates used to reflect the purchasing power of currencies, typically comparing prices among a broader range of goods and services than conventional exchange rates.
- The salaries and living expenses of many expatriate researchers working on donor-supported projects are paid directly by the donor agency and are often excluded in the financial reports of the agricultural R&D agencies. These *implicit* costs have been estimated using the average cost per researcher in 1985 to be $160,000 1993 international dollars and backcasting this figure using the rate of change in real personnel costs per fte researcher in the US state agricultural experiment station system. This extrapolation procedure has the assumption that the personnel-cost trend for US researchers is a reasonable proxy of the trend in real costs of internationally recruited staff in the agricultural R&D agencies.

See the ASTI website (http://www.ASTI.cgiar.org) for more details on methodology.

NOTES

1. The authors are grateful to numerous colleagues in Sudan for their time and assistance with data collection, Olympia Icochea for her assistance with data processing, and Abdalla Ahmed Abdalla, Osman Ageeb, Zohair Alabjar, Faisal Awad, Mohamed Osman Khidir, and Salih Hussein Salih for useful comments on drafts of this brief.
2. The 32-agency sample consisted of:
   - Four government agencies: the Agricultural Research Corporation ARC), the Animal Resources Research Corporation (ARRC), the Hydrology Research Station (HRS), and the National Research Centre (NRC);
   - 27 higher-education agencies: the University of Khartoum's Faculty of Agriculture, Faculty of Forestry, Faculty of Animal Production, Faculty of Veterinary Medicine, and Institute of Environmental Studies; Azhari University's Faculty of Agriculture; the University of Bakht Alruda's Faculty of Agriculture and Natural Resources; Sudan University of Science and Technology's College of Agricultural Studies and College of Veterinary Medicine and Animal Production; the University of Gezira's Faculty of Agricultural Sciences, Department of Food Science and Technology in the Faculty of Science and Technology, Faculty of Animal Production, and Abu Haraz Faculty of Agriculture and Natural Resources; the Univ ersity of Juba's College of Natural Resources and Environmental Studies; the University of Upper Nile's Faculty of Agriculture and Faculty of Animal Production; the University of Kassala's Faculty of Agriculture and Natural Resources; the University of Zalengi's Faculty of Agriculture; the University of Al-Fashir's Faculty of Natural Resources, the University of Gedarif's Faculty of Agriculture and Environmental Sciences; the University of Kordofan's Faculty of Natural Resources and Gum Arabic Research Centre; the University of West Kordofan's Faculty of Natural Resources and Environmental Sciences; the Nile Valley University's Faculty of Agriculture; the University of Dongola's Faculty of Agricultural Sciences; the University of Sennar's Faculty of Agricult ure and Faculty of Natural Resources and Environmental Studies; the Islamic University's Faculty of Agriculture; and
   - One business enterprise, the Kenana Sugarcane Company.

   This agency sample excludes two higher-education agencies involved in agricultural research: the Faculty of Veterinary Medicine of the University of Nyala, Southern Kordofan's Faculty of Agriculture, and the College of Forestry and Range Science of the Sudan University of Science and Technology.
3. With the inclusion of the three higher-education agencies for which data were unobtainable, these totals would be slightly —though not substantially —higher, given the omitted agencies are reported to conduct minimal agricultural research.
4. Unless otherwise stated, all data on research expenditures are reported in 1993 international dollars or in 1999 Sudanese dinars.
5. Established in 2001, MOST's mandate includes the formulation of applied research policies, planning and coordination of applied research activities, and funding of applied research projects at its institutes as well as at other research agencies, including universities and the private sector (MOST 2003).
6. ARRC did not reply to our numerous requests for information, so we estimated their researcher data using secondary sources (Beintema et al. 1995; Ageeb et al. 1999; Awad 2003); ARRC's spending data were estimated using ARC expenditure per researcher trends.
7. The Gezira Scheme is the largest irrigation scheme managed by a single entity in Sudan—and probably in the world. Ithas an irrigable area of about 883 million hectares, covers about half the country's irrigated area, and is centrally located between the Blue Nile and White Nile. The scheme provides a living for some 114,000 farmers and their families, incomes for additional seasonal and casual labor and sustains a large number of livestock. The scheme supports the production of about 65 percent of the country's cotton, 70 percent of its wheat, 32 percent of its sorghum, 15 percent of its groundnuts, and 20 percent of its vegetables. Operated by gravity, the scheme began in 1925 and thereafter formed the prototype for most of the large irrigation schemes in Sudan.
8. These CG centers include the International Center for Agricultural Research in the Dry Areas (ICARDA), the International Center for Maize and Wheat Improvement (CIMMYT), the International Center for Research in the Semi-arid Tropics (ICRISAT), the International Service for National Agricultural Research (ISNAR), the International Plant Genetic Resources Institute (IPGRI), and the International Livestock Research Institute (ILRI.
9. Data are calculated as least squares growth rates.
10. Averages for East and Central Africa in this brief include 8 of the 10 member countries of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA): Burundi, Ethiopia, Eritrea, Kenya, Madagascar, Sudan, Tanzania, and Uganda.
11. As of 2001, only the salary component of budgets has increased, but the recurrent and capital components remained unchanged.
12. IFAD financed the earlier phases of the NVRSRD project starting from 19979/80 until 1984/85, the Italian government took over from 1985/86 to 1987/88, and then the Government of the Netherlands sponsored later phases from 1988/89 to 1994/95 wh en funding ceased because of the political climate in the Sudan at the time. The Sudan, however, continued to be part of the network during 1995/96 to 1997/98 within NVRSRD was financed by the Netherlands Government.
13. Privately accepted students pay high fees (which can reach up to $4000 per academic year in some faculties such as medicine and engineering) and the practice has spread in recent years, generating substantial and increasing funds for public-owned universities.

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