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INVESTMENTS IN AFRICAN AGRICULTURAL RESEARCH

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ABSTRACT

Over the past three decades the development of agricultural research staff in sub-Saharan Africa has been impressive. There were significant increases in the number of researchers (a sixfold increase if South Africa is excluded), in Africanization (from about 90 percent expatriates in 1961 to 11 percent in 1991), and in education levels (over 60 percent of national researchers held a postgraduate degree in 1991).

Developments in agricultural research expenditures were less positive. After reasonable growth in spending throughout much of Africa in the 1960s and early 1970s, growth largely stopped in the late 1970s. Donors have been dominant and increasing sources of support for agricultural research in Africa; their share of total agricultural R&D funding (excluding South Africa) grew from 34 percent in 1986 to 43 percent in 1991 -- 49 percent in 1991 if the large and largely locally funded Nigerian system is also excluded. Moreover, an analysis of government spending patterns provides evidence that many of the countries throughout Africa have shifted public investment priorities away from agricultural research. But these overall patterns of development mask important differences between countries and among institutions within countries and these differences have real policy consequences.

Many of the developments of the past decade in personnel, expenditures, and sources of support for public-sector R&D in Africa are not sustainable. The rapid buildup of research staff is not paralleled by an equal growth in financial resources. Spending per scientist has continuously declined during the past 30 years, but most dramatically during the 1980s. Resources are spread increasingly thin over a growing group of researchers, which has negative effects on the efficiency and effectiveness of agricultural research.

CONTENTS

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Philip G. Pardey, Johannes Roseboom, and Nienke Beintema[***]

1. INTRODUCTION

There is a perception the world over that public agricultural research systems need to be revamped and revitalized. This perception is particularly prevalent regarding African agricultural research systems. After significant increases in investments in public-sector agricultural R&D throughout much of Africa in the 1960s and 1970s, the 1980s saw a reversal of this trend. Growing levels of international indebtedness and programs of structural adjustment spurred government austerity programs that curtailed public-sector spending in general and scaled down public investments in agricultural research. Bilateral and multilateral grants and loans made up for some of the shortfall although many national systems experienced stagnant or declining amounts of real support over recent years.

Consequently, renewed attention is being paid to the policy options for public agricultural research in Africa and elsewhere. To meaningfully think through these options requires a good grasp of the current situation regarding African agricultural R&D and some understanding of the history behind the present policies and institutional arrangements. Our intent in this paper is to use an entirely new data set to quantitatively

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[*]This paper is one in a series of papers being prepared as part of the IFPRI/ISNAR "Agricultural Research Policy in Africa" project jointly sponsored by DANIDA, SPAAR-World Bank, and USAID.

[**]Previous accounts of the development of African agricultural R&D are given by Lipton (1988), Lele, Kinsey, and Obeya (1989), Eicher (1990), Pardey, Roseboom, and Anderson (1991), Anderson, Pardey, and Roseboom (1994), and Pardey, Roseboom, and Beintema (1995).

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review the past and present patterns of investments in African agricultural research as a basis for formulating appropriate policy options for agricultural research in the region.[1] In presenting and commenting on investments in public research we note the growing awareness that simply seeking more dollars is not the answer. The financing, organization, and management of public R&D will have to be dealt with in an integrated way (Alston and Pardey 1995a and b).

This paper is organized as follows. Section 2 gives a brief historical description of institutional developments regarding national agricultural research systems in sub-Saharan Africa (referred to as Africa hereafter). Historical antecedents are helpful in understanding more recent developments. Next, in section 3 we describe the pattern of growth of R&D personnel and section 4 presents similar data on R&D expenditures, highlighting geographical and institutional differences in spending per scientist and cost structures more generally. In section 5 we give more detail on the financing of agricultural R&D in Africa paying particular attention to the marked differences in sources of support among government and semi-public agencies, changes in various measures of research spending intensities, and the role of donors in supporting African agricultural R&D. Section 6 concludes the paper.

[1]The data summarized in this paper are reported in a series of country statistical briefs. The series were compiled from information obtained from a detailed, institutional level survey of national agricultural research agencies and, where necessary and appropriate, available secondary sources. The data were collected and compiled using international standards laid down in the Frascati manual for developing science indicators (OECD 1981). FAO (1993 and 1994) also present some data on African agricultural R&D.

2. INSTITUTIONAL DEVELOPMENTS

A BRIEF HISTORY **ERROR! BOOKMARK NOT DEFINED.**

Formalized agricultural research in Africa began around 1900. Much of the early work was conducted at the botanical gardens established throughout the region in the late 19th century. Initially this work dealt largely with the introduction, screening, and propagation of tropical export crops. Eventually these activities moved beyond simply screening and importing new materials to developing improved agronomic practices, breeding improved crops and livestock, and investigating methods to control pests and diseases.

In the early 1900s colonial governments set up experiment stations that gradually assumed the research role previously met by the botanical gardens. These stations laid the foundation for a fledgling agricultural research infrastructure in sub-Saharan Africa. By 1920 at least one station or site had been established in virtually every country in the region. Most stations were controlled and financed by local colonial governments with technical support from the respective colonial metropolises. South Africa is an important exception to this general pattern of development. By 1910 the country was an independent state within the British Commonwealth and went on to develop the largest and arguably the most successful agricultural research system on the continent.[2]

As the number of research stations continued to expand throughout the 1920s and 1930s, efforts were taken to coordinate, organize, and execute research in ways that made sense from a regional as well as a local or national perspective. For example, in French

[2]Although South Africa was politically independent, the cultural and scientific links with Great Britain and The Netherlands were substantial until about 1960. For example, many of the older South African researchers received their postgraduate training in Great Britain or The Netherlands. In addition, South Africa attracted many young scientist from Europe.

West Africa, which operated as a federation, agricultural research was largely organized at the federal level. Such a mode of operation was consistent with the political and economic interests at that time. Colonial governments pursued policies that maximized regional rather than national returns to investments in agricultural research. Immediately following World War II, both France and Great Britain substantially restructured their research operations and increased their financial and technical support to research throughout their African colonies.

In the British colonies a two-tiered research system evolved. Regional agricultural research entities were established that emphasized basic, less site-specific research, as well as research on economically important export commodities such as cacao, coffee, and tea. The more applied and adaptive research was done by the respective national research agencies.

In the French colonies much of the existing research infrastructure was eventually consolidated into a number of tropical research institutes that were administered collectively. By 1960 there were eight such institutes working in specific areas or commodities such as coffee and cacao, palm oil, cotton, forestry, and veterinary medicine. In a marked departure from the regionalized but administratively decentralized British model, these French institutes were headquartered in and managed from France. Satellite research stations were located in the various colonies.

With political independence in the late 1950s and early 1960s, most African countries inherited agricultural research structures that operated as part of a regionalized system. As the old colonial structures collapsed many smaller countries found themselves effectively cut off from the network of research services to which they previously had

direct access. Other countries were left with highly specialized research agencies that did not necessarily address local production problems. There were major incongruencies across countries regarding the existing research capacity. Moreover, research was largely oriented to meeting the demands of export agriculture and paid little attention to the production constraints faced by subsistence farmers.

The transition to post-independence followed different paths in the former British and French colonies (see also Eisemon, Davis, and Rathgeber 1985). Throughout much of anglophone Africa the local agricultural research infrastructure and administrative control was ceded to the new governments as an integral part of the country's administrative structure. In many cases, the flow of financial and technical support for research from Great Britain to its former colonies contracted quite quickly, leaving the responsibility for financing and managing research facilities fully vested with the incoming governments.

In contrast, France continued to manage, execute, and fund agricultural research in most of her former colonies for many years following political independence. A series of bilateral agreements between France and the host governments were signed wherein research costs were shared. In most instances France continued to provide scientists and related costs while the host country provided support staff. Eventually these arrangements collapsed as domestic governments sought complete managerial and financial control over the research agencies operating in their countries.

As a consequence of these developments, the Africanization of agricultural research occurred more slowly in francophone Africa than in anglophone Africa. In 1991, for example, about 21 percent of the researchers working in francophone Africa

were expatriates compared with about 7 percent in anglophone Africa. Moreover, the indigenous capacity to train students in the agricultural sciences is still much more limited in francophone Africa than in anglophone Africa.

SIZE

During the past three decades African national agricultural research systems (NARSs) grew substantially in size. Particularly, the number of mid-sized systems (those employing 100-400 researchers) increased. While in 1961 there were only three such systems, by 1991 this number had grown to 18 (Table 1). Similarly, only eight NARSs in Africa currently employ less than 25 full-time equivalent researchers. This compares with 33 systems three decades ago.

In 1961, South Africa, the only country with more than 200 full-time equivalent (fte) researchers at that time, employed an estimated 740 fte researchers (Roseboom et al. 1995). Currently South Africa employs about 1,400 fte researchers. In contrast, the Zairian NARS, by many accounts once one of the better research systems in the tropics, was staffed with more than 200 fte researchers prior to 1961 but completely collapsed after the country gained independence in 1960. The entire expatriate Belgian community, including all of the expatriate researchers working in Zaire at the time, fled the country during the army mutiny and civil war that followed independence.

Table 1—Size of African agricultural research systems, 1961 and 1991

	1961		1991	
Size of NARSs[a]	Number of NARSs	Share of NARSs	Number of NARSs	Share of NARSs
0-24	33	68.8	8	16.7
25-49	5	10.4	7	14.6
50-99	6	12.5	11	22.9
100-199	3	6.3	10	20.8
200-399	0	0	8	16.7
400-999	1	2.1	2	4.2
>1000	0	0	2	4.2
Total	48	100	48	100

[a] Grouped according to number of full-time equivalent researchers.

Three decades later the research system has yet to recover. Similar events befell research systems in Angola, Mozambique, and, Uganda and more recently in Liberia, Rwanda, Somalia, and parts of the Sudan.

INSTITUTIONAL STRUCTURE

Public and Semi-public Research

Public-sector agricultural research in Africa is done mainly by government agencies. Semi-public agencies and universities play only a minor role (Table 2).

Government R&D agencies are those directly or indirectly administered by government, which in practice often means the research departments of ministries of agriculture or agricultural research institutes directly under a ministry. In contrast,

Table 2—Sectoral composition of African NARSs

Category	Share of FTE researchers				Annual growth rate[a]
	1961	1971	1981	1991	1961-91
	(percentage)				
Government	90.7	89.1	89.0	86.5	5.0
Semi-public	4.2	3.8	3.1	3.5	3.6
Academic	5.1	7.1	7.9	10.0	7.1
Total	100	100	100	100	5.1

Note: Sample size 21 countries.
[a] Growth rates were calculated using a least squares regression method.

semi-public agencies are not directly controlled by government and have significant autonomous sources of funding, usually a compulsory cess or marketing-board profits.[3] They usually provide R&D services for a particular, and often economically significant export commodity. Examples include agencies doing research on coffee (Kenya), sugar (Mauritius and South Africa), tea (Kenya and Malawi), and tobacco (Zimbabwe).

All the semi-public research institutes noted in this study were in former British colonies. None were evident in the former French colonies. Virtually all semi-public agencies were established during colonial times; very few such agencies have been established since 1961. In consequence, they make up a declining share of the human resources going to agricultural research (4.2 percent of the research staff in 1961 compared with 3.5 percent in 1991).

[3]Semi-public research agencies constitute those agencies not directly controlled by government and with no explicit profit-making objective. Thus we required an agency be governed by an autonomous (i.e., non-government appointed) board and also exhibit a certain degree of financial independence from the government before classifying it as a semi-public agency. As a practical matter an agency was classified as a semi-public operation if it received more than 25 percent of its income from sources other than government and international donors and was autonomously governed.

University Research

University-based agricultural research has expanded markedly. The total time spent by university faculty doing research in the agricultural and related sciences grew on average by 7.1 percent per annum during the past three decades; 10 percent per annum if South Africa is excluded. In 1961 only a few countries provided any tertiary training in the agricultural sciences. Now, almost all African countries have some capacity to train students to the BSc level in the agricultural sciences. Considerably fewer countries, however, can provide postgraduate training.

Despite the rapid growth in university-based agricultural R&D in Africa, this sector still accounts for only 10 percent of the overall full-time equivalent agricultural researchers in the region. Initially, university faculty throughout post-independence Africa were virtually fully occupied educating graduates to staff the newly emerging national bureaucracies. Although the time they spent doing research gradually grew over the years, most faculty still dedicate less than 15 percent of their time to this endeavor. Further, the research they do is mainly discipline-based rather than applied research aimed at solving specific production problems faced by farmers. Nevertheless, university personnel represent the better qualified component of most NARSs. The challenge is to usefully mobilize and manage this highly fragmented potential without undermining (and indeed hopefully enhancing) their important role in training the next generation of African researchers.

3. R&D PERSONNEL

OVERALL TRENDS

Many African countries have made significant strides in the number of scientists working in their agricultural research agencies. In 1961 there were about 2,000 full-time equivalent researchers working in sub-Saharan Africa (including South Africa). By 1991 this number had grown to more than 9,000[4]. For 21 countries, accounting for about 75 percent of the region's researchers, more complete time-series data are available (Table 3). Building from a rather small base that was initially made even smaller by the exodus of expatriate scientists in the years immediately following independence, the number of scientists grew by 6.4 percent throughout the 1960s, 5.1 percent in the 1970s, and slowed further to average 3.0 percent per annum in the 1980s. These totals mask a good deal of cross-country variation. Agricultural research staff in Ethiopia, Madagascar, Rwanda, and Togo grew by 8 percent to 10 percent per annum during the 1980s, while the number of scientists working in Botswana, Nigeria, and Senegal failed to grow during this decade.

EXPATRIATE RESEARCHERS

The composition of the scientific workforce has also undergone substantial change. Expatriates account for only 11 percent of the researchers currently working in national agencies throughout sub-Saharan Africa (excluding South Africa), down dramatically from 90 percent in the early 1960s and 30 percent or so in the early 1980s. However, this percentage varies widely among countries. In 1991 more than

[4]This total includes 48 African NARSs. For 11 (usually small) national systems an informed estimate, often involving extrapolations from secondary data or semi-processed but incomplete survey data, was made in constructing the respective 1961 and 1991 regional totals. These data exclude personnel working at or for international or regional agencies.

Table 3—Full-time equivalent researchers working in African NARSs

Country	Total number of FTE				Annual growth rate[a]			
	1961	1971	1981	1991	1961-71	1971-	1981-91	1961-
	(full-time equivalents)				(percentage)			
Botswana	1.1	16.3	46.5	53.9	31.9	11.1	-0.2	12.5
Burkina Faso	10.1	25.3	90.9	142.4	11.3	12.3	2.8	9.8
Cote d'Ivoire	66.7	135.4	191.8	266.5	6.4	3.9	3.7	4.2
Ethiopia	14.0	65.9	153.0	386.8	17.1	7.3	9.6	11.0
Ghana	56.6	131.7	180.1	277.9	9.6	2.8	4.4	4.2
Kenya	120.8	325.9	483.6	818.7	10.5	3.0	4.8	6.4
Lesotho	1.0	7.0	16.8	27.5	19.2	8.3	5.2	10.4
Madagascar	69.6	113.8	95.0	194.7	5.2	-2.7	8.6	2.2
Malawi	30.2	80.8	126.2	184.9	12.0	4.8	3.2	6.1
Mauritius	11.7	39.1	72.5	106.1	12.9	5.7	3.8	7.3
Niger	11.5	14.4	49.5	101.6	1.0	17.6	6.6	9.3
Nigeria	136.0	364.4	944.3	1012.8	10.4	10.8	-0.3	7.5
Rwanda	5.0	16.0	28.3	57.1	9.0	7.0	9.5	8.8
Senegal	60.0	71.4	184.3	174.5	2.2	11.5	-1.1	5.4
South Africa	736.8	956.8	1140.4	1339.1	2.7	1.6	1.3	2.0
Sudan	48.0	125.2	324.0	424.4	9.4	8.6	2.3	8.4
Swaziland	6.0	12.4	5.4	19.9	5.7	-9.8	5.6	3.8
Zambia	25.7	100.8	174.7	279.4	14.4	4.6	4.1	8.0
Zimbabwe	114.4	166.5	173.2	290.8	3.4	-0.5	5.9	2.7
Subtotal (19 countries)	1525.2	2769.1	4480.6	6158.9	6.2	4.8	2.8	4.9
Tanzania	48.7	142.3	345.2	545.9	11.9	8.6	3.9	8.8
Togo	2.3	15.0	38.2	87.1	20.2	9.3	9.7	11.6
Total (21 countries)	1576.2	2926.4	4864.0	6791.9	6.4	5.1	3.0	5.1

Note: These data include crop, livestock, forestry, and fisheries researchers working in government, semi-public, and academic agencies. Tanzania and Togo are listed separately because no corresponding expenditure time-series data are currently available.

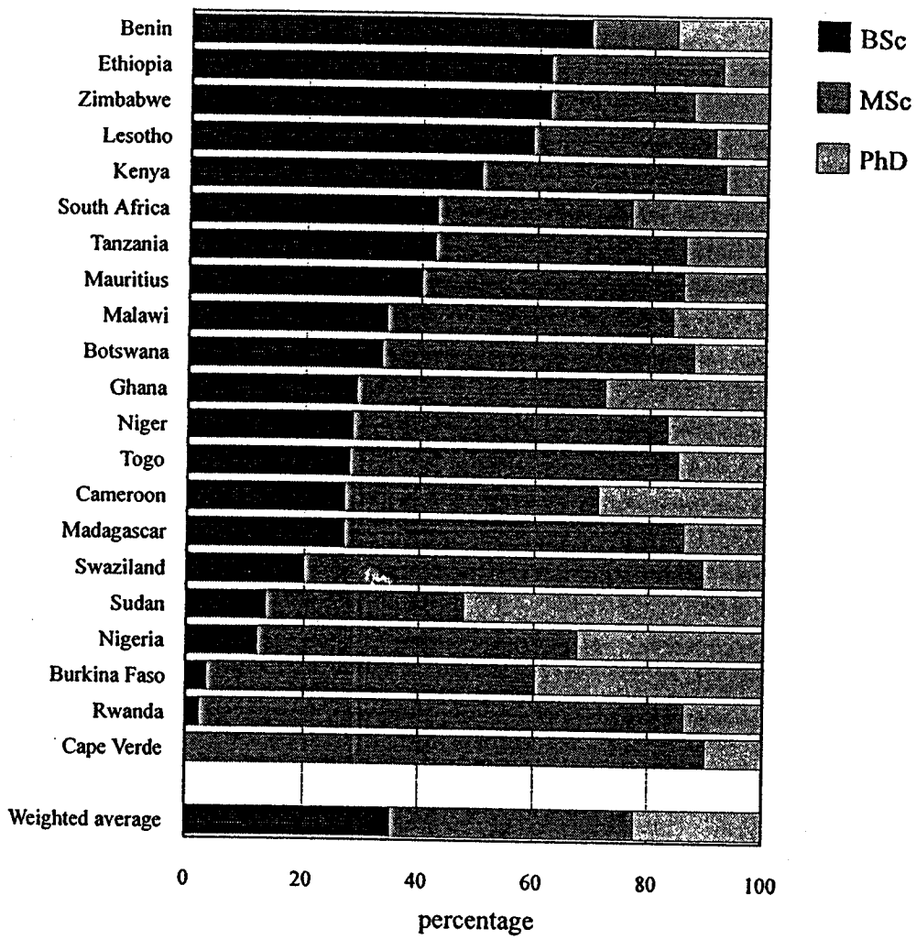
[a] Growth rates were calculated using a least squares regression method.

a quarter of the agricultural scientists working in Botswana, Cape Verde, Central African Republic, Cote d'Ivoire, Mozambique, Rwanda, Senegal, and the Seychelles were expatriates. In Nigeria, Mauritius, South Africa, Sudan, and Tanzania they constituted less than 5 percent of the total. Former French colonies typically employ a higher proportion of expatriate researchers than former British colonies, reflecting the comparatively slower transition to full national control of local agricultural research facilities in the francophone countries.

DEGREE STATUS

Not only has the number of agricultural researchers in Africa increased fourfold since 1961 (sixfold if South Africa is excluded), but their levels of formal training have improved as well. Nearly 65 percent of the national researchers in the 21 countries included in figure 1 have postgraduate degrees. Just a decade ago only 45 percent were trained to that level. An estimated 1,372, or about 22 percent, of these researchers hold a doctoral degree, although 63 percent of these doctorates work for just three NARSs: Nigeria, South Africa, and Sudan. Indeed, 52 percent of the researchers working in Sudan hold a PhD, which is an exceptionally high proportion compared with most other countries.

Figure 1—*Degree Level of National Researchers, 1991*



4. R&D EXPENDITURES

Real agricultural research expenditures grew rapidly during the 1960s, moderately during the 1970s, and ceased to grow throughout the 1980s and early 1990s for the 19 country sample reported in Table 4. But the more detailed data reveal a substantial degree of volatility and cross-country variation around this trend. Long-term growth rates ranged from a high of 13.2 percent per annum for Botswana to a low of -2.4 percent for Madagascar. The pattern of growth in Nigeria's agricultural research expenditures is noteworthy. After substantial growth during the 1960s and 1970s, largely financed by revenues from a booming oil sector, Nigeria's agricultural research expenditures contracted sharply during the 1980s. Total expenditures are presently less than half what they were in the late 1970s.

Making meaningful comparisons of agricultural research expenditures across countries and over time is fraught with difficulties. Beginning with value aggregates (such as total spending on agricultural R&D) denominated in nominal local currencies and converting them to internationally comparable measures of the *real* resources used to perform agricultural R&D requires dealing with differences in prices over time and between countries. To do so one is forced to use deflators and exchange rates that are less than ideal. A generally preferred procedure, and the one used in Table 4, is to first *deflate* expenditures expressed in current local currency

Table 4—Agricultural Research Expenditures by African NARS

	Research expenditures				Annual average growth rate[a]			
Country	1961	1971	1981	1991	1961-	1971-81	1981-91	1961-91
	(million 1985 PPP dollars)				(percentage)			
Botswana	0.18	2.67	10.84	9.82	30.3	13.8	-3.8	13.2
Burkina	1.61	2.85	7.11	19.13	7.9	9.3	9.5	8.1
Cote	18.04	34.69	39.39	37.61	5.5	1.1	0.1	1.8
Ethiopia	1.90	9.19	21.14	40.53	19.4	7.7	10.6	10.4
Ghana	12.15	17.92	13.54	32.52	4.8	-3.2	14.4	2.1
Kenya	22.36	49.69	62.28	95.97	8.4	1.7	4.0	4.4
Lesotho	0.25	1.85	3.78	3.60	20.6	6.6	-1.8	8.1
Madagascar	17.89	29.28	11.45	15.63	4.7	-7.4	3.0	-2.4
Malawi	8.11	17.36	21.95	27.31	9.9	2.4	2.4	4.0
Mauritius	3.20	7.59	9.63	12.63	9.1	1.8	1.3	4.0
Niger	1.99	4.31	8.04	9.83	8.2	12.6	3.9	6.7
Nigeria	42.15	92.07	211.86	86.90	6.4	7.1	-9.1	1.9
Rwanda	1.97	3.63	5.77	10.03	5.8	6.7	11.4	5.7
Senegal	17.82	25.48	37.36	23.85	2.9	4.7	-4.3	2.7
South	74.91	140.47	140.17	163.93	6.0	-0.6	1.8	2.0
Sudan	12.99	34.94	39.90	21.46	9.9	0.5	-5.5	1.5
Swaziland	1.05	2.87	3.53	5.89	8.4	-1.2	-2.4	6.6
Zambia	4.18	14.81	19.66	24.67	14.3	4.0	-0.0	5.3
Zimbabwe	13.61	26.43	33.65	43.25	6.3	1.1	4.2	3.6
Total (19)	256.37	518.10	701.03	684.55	6.8	2.6	0.1	2.9

Note: Data correspond in coverage with Tables 2 and 3.
[a] Growth rates were calculated using a least squares regression method.

with a local, implicit GDP deflator to base year 1985 and then *convert* the expenditures to constant, 1985, purchasing-power-parity (PPP) dollars.[5]

PPPs are synthetic exchange rates that attempt to get a broader measure of relative currency values by comparing a detailed basket of internationally traded and non-traded

[5]Ideally one would like disaggregated data that report the quantities and prices of the different inputs to R&D such as the number and salaries of scientists of different classes and support staff, consumables such as chemicals and test tubes, operating costs such as travel, electricity, and so on. Then various index number procedures can be applied in a systematic way to minimize the biases involved in adding all these inputs in ways that generate economically meaningful aggregates. In the absence of such disaggregated data one is forced to use other, short-cut procedures as we have done here to deal with over time and cross country price differences. Pardey, Roseboom, and Craig (1992) discuss these issues in some detail and provide recommendations for coming up with comparable measures using less than ideal data on agricultural R&D inputs.

goods and services; official market exchange rates by comparison are based only on a basket of internationally traded goods and services. Given that a large share of the resources committed to agricultural R&D consists of the non-traded labor services of scientists and support staff, conversion factors (such as the PPPs we use) that incorporate the relative prices of these non-traded services is to be preferred if the intent is to get a meaningful comparison of the real resources committed to R&D. Moreover the managed exchange rates common throughout Africa are often subject to significant government-induced distortions that make them less useful for translating real purchasing power. The fact that official market exchange rates can and do change in sudden and significant ways also makes the choice of an appropriate base year in which to do the currency conversion problematic. PPPs are, by construction, much less sensitive to such distortions.

Table 5 presents research expenditure data expressed in U.S. dollars rather than PPP dollars as reported in Table 4. The same underlying expenditure data were first deflated to base year 1985 local currency units when constructing both series; the only difference is that PPPs were used for the currency conversions in Table 4 while official market exchange rates were used in Table 5. The Table 5 figures (erroneously) suggest a much smaller volume of resources being committed to agricultural R&D in Africa than the Table 4 data; 305 million (base year 1985) U.S. dollars in aggregate compared with 685 million PPP dollars. It is noteworthy, however, that the procedures we use to deflate and convert research expenditures to a base year, numeraire currency do not affect

measured rates of growth; growth rates of expenditures denominated in PPP dollars are identical to those denominated in U.S. dollars.[6]

RESOURCES PER RESEARCHER

Overall Trends

The pattern of growth of real research expenditures is in stark contrast with that of research personnel. The number of research personnel and the amount of resources committed to research developed largely in parallel from 1961 to 1981 but thereafter followed dramatically different paths (Figure 2a). Real expenditures stalled after 1981 while the number of researchers continued to climb. As a result, the quantity of resources per researcher in 1991 for this group of 19 countries averaged about 66 percent of the amount allocated in 1961.

[6]This is not generally true. Many analysts first convert expenditures dominated in local currency units to U.S. dollars and then deflate to base year prices using a U.S. deflator (see, for example, Evenson and Kislev 1975). The invariance properties of our estimates would not usually apply in such cases.

Table 5--Agricultural research expenditures by African NARSs—US dollars denominated estimates

Country	Total agricultural research expenditures			
	1961	1971	1981	1991
	(million 1985 US dollars)			
Botswana	0.07	1.01	4.09	3.71
Burkina Faso	0.43	0.76	1.89	5.08
Cote d'Ivoire	8.49	16.33	18.54	17.70
Ethiopia	0.66	3.20	7.35	14.08
Ghana	7.13	10.51	7.94	19.07
Kenya	7.90	17.56	22.01	33.91
Lesotho	0.03	0.24	0.49	0.47
Madagascar	6.07	9.94	3.89	5.30
Malawi	2.17	4.63	5.86	7.29
Mauritius	0.90	2.13	2.71	3.55
Niger	0.72	1.55	2.90	3.54
Nigeria	35.81	78.23	179.99	73.83
Rwanda	0.77	1.41	2.24	3.90
Senegal	6.02	8.60	12.62	8.05
South Africa	30.40	57.00	56.87	66.52
Sudan	5.73	15.41	17.60	9.47
Swaziland	0.25	0.68	0.84	1.40
Zambia	1.84	6.53	8.67	10.87
Zimbabwe	5.32	10.34	13.16	16.92
Total (19)	120.67	264.04	369.64	304.66

Only Botswana, South Africa, Swaziland, and Zimbabwe committed more real resources per scientist in 1991 than was the case three decades earlier.

The national research systems in Nigeria and South Africa -- two countries that together accounted for 37 percent of the region's total investment in agricultural R&D in 1991--developed in distinctively different ways during the past 30 years (Figures 2c and 2d). The South African system grew slowly but steadily and the rate of growth of its real research expenditures kept pace with the growth of its research staff. These

comparatively sedate but balanced institutional changes typify the pattern of growth of a more mature and reasonably well developed system.

In contrast, the Nigerian system had an erratic pattern of development. Fueled by a boom in public revenues from oil exports, research spending and staff numbers grew rapidly during the 1960s and 1970s. But during the 1980s research spending declined dramatically while the number of research staff stayed constant. The drop in research spending not only coincided with the collapse of overall government revenues but also reflected a shift in government priorities away from agricultural R&D. Public spending on agricultural research accounted for 0.84 percent of consolidated government expenditures in 1981 but a mere 0.27 percent in 1991. The earlier rapid growth in the Nigerian NARS was characteristic of NARSs throughout the region at that time. Many African countries pursued policies that led to a rapid growth in their national agricultural research systems, though often from a small base.

Excluding the Nigerian and South African systems from the African average changes the quantitative but not the qualitative spending-per-scientist picture presented above. The number of research personnel in the 17 country sample in

Figure 2—*Research Staff and Expenditures, 1961-91*

Figure 2a: 19 country sample
index (1961=100)

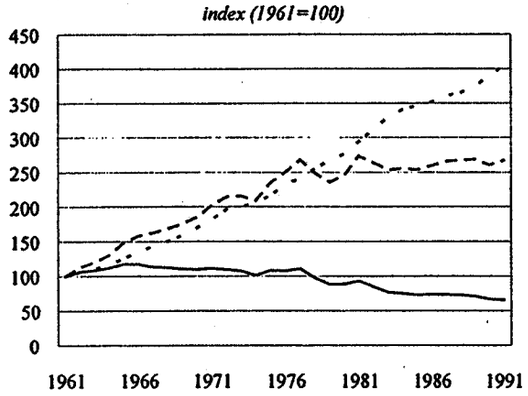


Figure 2b: 17 country sample
index (1961=100)

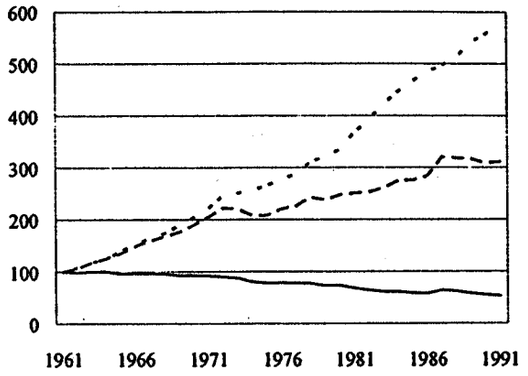


Figure 2c: Nigeria
index (1961=100)

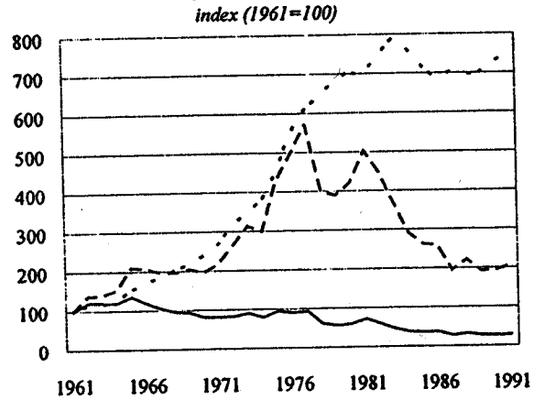
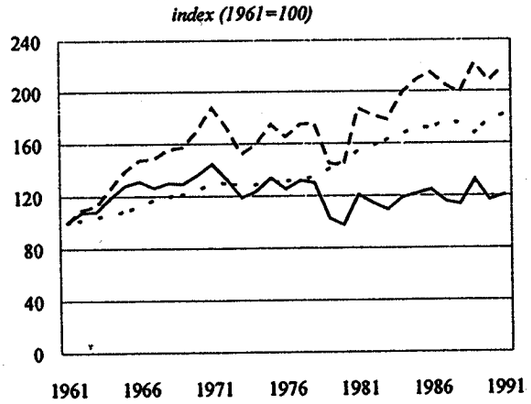


Figure 2d: South Africa
index (1961=100)



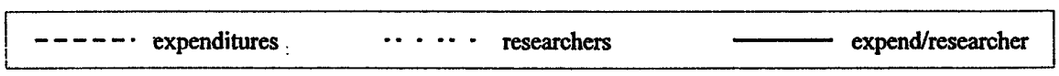


figure 2b continued to climb throughout the post-1961 period as it did for the 19 country sample plotted in Figure 2a. For the larger group of countries growth in real research spending ceased after 1981 while for the smaller group of countries it continued to grow throughout the whole period -- albeit much more slowly after 1971 compared with the 1960s. Thus excluding these two large countries from the sample dampens the rate of decline in overall spending per scientist compared with the rate noted above for the larger sample, but the decline began much earlier. As a consequence, spending per scientist for this 17 country sample in 1991 had fallen to about 53 percent of the resources made available per scientist three decades earlier.

Regional Patterns

Since 1961 both the number of research staff and the amount of expenditures grew more slowly in francophone than in anglophone Africa[7]: respectively, 5.0 percent and 6.4 percent per annum for research staff and 2.2 percent and 3.3 percent per annum for expenditures. However, spending per scientist is about 20-25 percent higher in francophone compared with anglophone countries. This partly reflects the higher dependence on relatively expensive expatriate researchers in francophone Africa and, perhaps, more generous operational and capital support to these French-managed institutes.

Institutional Patterns

Government and semi-public agencies developed in very different ways. Since the large majority of the full-time equivalent researchers work in government agencies, the country aggregates are driven mainly by developments in those agencies. Overall

[7]The countries included in the francophone sample are Burkina Faso, Côte d'Ivoire, Madagascar, Niger, Rwanda, and Senegal; and in the anglophone sample, Botswana, Ghana, Kenya, Lesotho, Malawi, Mauritius, Nigeria, Sudan, Swaziland, Zambia, and Zimbabwe.

spending per scientist fell by 1.6 percent per annum since 1961. This ratio grew by a modest 0.5 percent per annum throughout the 1960s, then declined by 1.8 percent per annum during the 1970s and by 2.4 percent per annum in the 1980s. This contrasts starkly with developments in semi-public agencies.

Figure 3 reports spending per scientist ratios for eight major semi-public institutes spread across five countries, employing 236 researchers, and spending 50.4 million (1985 PPP) dollars in 1991. For these agencies, the growth in real expenditures slightly exceeded the growth in personnel. Their spending per scientist ratio in 1991 was 12 percent higher than in 1961 compared with 36 percent lower for the government agencies. These spending per scientist patterns reflect a number of factors. Aside from the obvious asymmetries between the growth in total spending and the growth in the number of scientists supported by those expenditures, there are dramatic differences across agencies and changes over time in the *composition* of these personnel and expenditure aggregates.

There were several partially offsetting developments regarding the researcher aggregates. First there was a widespread move to replace relatively expensive expatriate scientists with less costly national researchers. Working in the opposite

Figure 3—*Research Staff and Expenditures by Type of Institute, 1961-91*

Figure 3a: government agencies
index (1961=100)

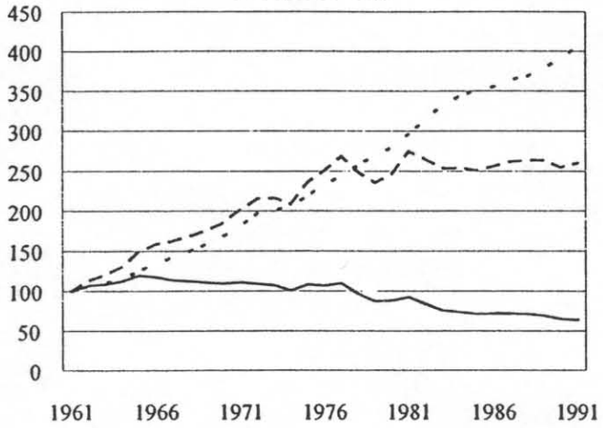
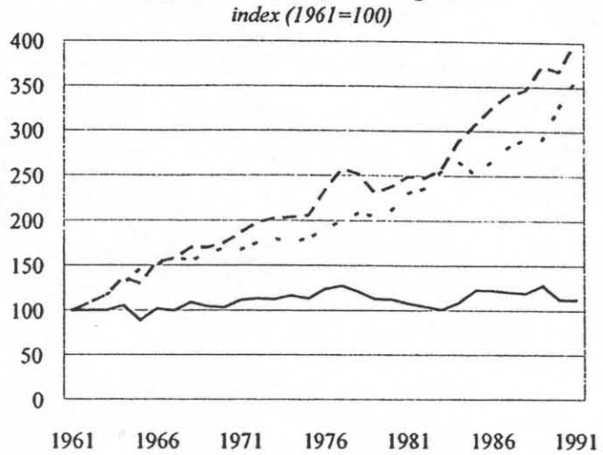
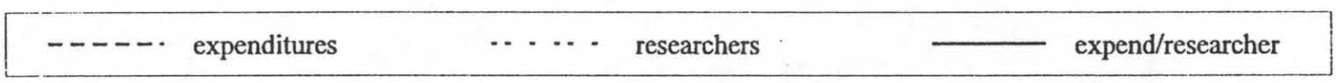


Figure 3b: semi-public agencies
index (1961=100)





direction was the considerable upgrading of the degree status of local scientists. The training and additional salary costs implied by these developments are substantial. Another aspect that affects spending per scientist estimates is the size and composition of the support staff. Although some research agencies shed excess support staff in recent years, this tendency has been far from universal. Overstaffing with support personnel is still a problem for many government research agencies. In addition, changes in the mix of support staff -- for example, semi-skilled versus trained technical staff -- are also relevant in this regard.

Similar, and clearly related issues are reflected in the cost structures that underlie the expenditure aggregates. Systems that undergo major programs of capital investments are likely to have higher spending per scientist ratios than those that simply maintain existing physical infrastructure. Although no comprehensive cost-share data for the earlier years are available, fairly adequate data do exist for the post-1985 period. These data suggest that overall cost *shares* were reasonably stable throughout this period, although, real spending per scientist, at least in the aggregate, continued to decline (Table 6).

The stability in these overall cost shares belies dramatic inter-institutional differences in the underlying cost structures. Table 6 also reports the cost components for government and semi-public institutes on a per-researcher basis. The amount of real resources per scientist in the semi-public institutes is nearly twice that of the government institutes, and this difference persists across the personnel, operating, and capital cost components. This points to significant, and possibly very important, differences in the way government and semi-public agencies allocate their research budgets.

The anecdotal evidence suggests that research, particularly in government agencies throughout Africa, is severely curtailed because of inadequate operational resources. The quantitative evidence in Table 6 seems to contradict this view, particularly for the semi-public institutes. But, it may be that a disproportionate share of operational funds is consumed by burdensome administrative overhead and the maintenance and upkeep of an extensive network of (comparatively small) research stations and farms. This seems especially so for government agencies. These funds might never find their way into bench-level research. For the semi-public institutes, the relatively high operational costs per researcher may partly arise because these institutes commonly earn much of their income from estate farm operations that employ significant numbers of field staff. Disentangling farm costs from research-related costs is difficult.

Certainly the evidence in Table 6 clearly points to the salary crunch that has bedeviled scientists working in government agencies. Researchers' salaries are constrained by civil service regulations, which often do not adequately reflect the differences of conducting R&D versus other government services. For many African countries the purchasing power of civil servants deteriorated dramatically during the past two decades because governments only partially compensated for inflation. The result has been widespread absenteeism in many research agencies as staff work at other, additional jobs. Research managers face a dilemma in dealing with this problem. Freeing resources by reducing staff is often made difficult by public-service regulations. Likewise these same regulations make it difficult to raise the salaries of scientists beyond the standard public-service salary structure.

US Dollar Denominated Comparison

For an alternative look at spending per scientist ratios, Table 7 presents the 1991 ratios in current U.S. dollars per researcher. As argued above (and also by others), market exchange rates do a poor job in cross-country and over time

Table 6—Cost components for research and development

	Expenditures per researcher						Cost shares					
Cost category	198	1987	1988	1989	1990	1991	198	1987	1988	1989	1990	1991
	(thousands 1985 PPP dollars)						(percentage)					
Government research agencies												
Personnel	74	68	71	72	67	67	59.3	56.0	57.1	59.1	60.3	61.2
Operating	35	32	33	32	30	27	27.7	26.2	26.5	26.1	26.7	24.9
Capital	16	22	20	18	14	15	13.0	17.7	16.3	14.9	13.0	14.0
Total	125	122	124	121	111	109	100	100	100	100	100	100
Semi-public research agencies												
Personnel	130	111	119	118	104	103	52.2	49.6	51.0	46.3	47.1	50.4
Operating	83	76	76	82	77	72	33.3	34.1	32.5	32.1	34.9	35.0
Capital	36	36	38	55	40	30	14.4	16.2	16.4	21.6	18.0	14.6
Total	249	224	233	255	221	204	100	100	100	100	100	100
Total research agencies[a]												
Personnel	76	70	73	73	68	68	58.8	55.6	56.7	58.1	59.3	60.4
Operating	36	34	34	33	31	29	28.1	26.7	26.9	26.5	27.3	25.6
Capital	17	22	21	19	15	16	13.1	17.6	16.3	15.4	13.4	14.0
Total	130	125	128	126	115	113	100	100	100	100	100	100

Note: These data cover the following 17 countries: Burkina Faso, Cape Verde, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mali, Mauritius, Niger, Nigeria, Rwanda, Senegal, South Africa, Togo and Zimbabwe. The personnel cost data represent the salaries and benefits received by both national and expatriate researchers plus the personnel costs of all technical, administrative,and other support staff. All cost data are then divided by the number of full-time-equivalent researchers.
[a] Government plus semi-public agencies.

comparisons of volumes of resources.[8] We therefore caution against reading too much in the cross-country differences that can be noted in Table 7 as they may simply reflect

[8]Using official market exchange rates would be appropriate if all the inputs used to perform agricultural R&D consisted of imported items requiring foreign exchange to purchase. But as the data in Table 7 indicate, on average over two thirds of the labor used in agricultural R&D in Africa is locally hired and a

exchange rate distortions rather than real differences in the volume of resources available per researcher. However, it is common for donors and others who actually fund research to denominate spending aggregates in dollars using official market exchange rates. To facilitate the use of these new data in an operational context, and to provide a point of comparison to the PPP dollar aggregates, Table 7 reports U.S. dollar denominated expenditures per researcher for those countries for which we have appropriate data in 1991.

5. FUNDING AGRICULTURAL R&D

The common claim is that market failures in agricultural R&D lead to underinvestment in research if left to the private sector; research opportunities that would be socially profitable go unexploited. These market failures arise because some research is privately unprofitable due to appropriability problems -- whereby the innovator (or investor) cannot appropriate all the benefits -- or the transaction

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sizable share of the operational and, perhaps, even capital costs also consist of locally not internationally traded goods and services.

Table 7—Expenditures per researcher by cost category in US dollars (1991)

	Salaries					
Country	Local	TA[a]	Total	Operating	Capital	Total
	(current dollars per researcher)					
Burkina Faso	21,46	33,117	54,586	22,074	22,056	98,716
Cape Verde	36,56	41,379	77,939	30,330	4,678	112,94
Cote d'Ivoire	35,87	56,471	92,349	25,316	2,707	120,37
Ethiopia	16,17	8,586	24,757	10,530	10,088	45,374
Ghana	25,07	10,185	35,259	9,859	22,813	67,930
Kenya	19,11	12,660	31,778	10,771	6,772	49,320
Madagascar	11,72	25,140	36,866	8,680	2,664	48,210
Malawi	20,05	22,599	42,653	19,133	7,477	69,262
Mali	14,67	16,190	30,866	12,173	8,812	51,851
Mauritius	35,30	0	35,307	25,737	9,298	70,341
Niger	34,13	27,273	61,407	3,920	1,615	66,942
Nigeria	9,748	1,812	11,560	5,477	4,490	21,527
Rwanda	28,81	36,735	65,547	17,072	4,533	87,152
Senegal	34,48	45,031	79,515	17,965	3,498	100,97
South Africa	66,08	0	66,088	18,929	6,133	91,150
Togo	20,75	30,000	50,753	15,079	6,115	71,946
Zimbabwe	34,61	16,744	51,355	15,791	9,281	76,426
Weighted average	30,026	12,760	42,786	13,505	7,087	63,377

[a] TA indicates technical assistance.

costs involved in having farmers take collective action to finance (or execute) research that is beyond their individual reach are too high. Alston and Pardey (1995b) give a comprehensive and critical review of the evidence regarding market failures in agricultural research and discuss the principles and practices involved in designing ideal arrangements to *finance* or *conduct* research.[9]

One of the principles Alston and Pardey propose for solving the underinvestment problem is that the solutions or arrangements one may recommend depend on which type of market failure we are attempting to rectify. Thus developing a

[9]See also Thirtle and Echeverria (1994) who discuss some of the roles of public and private agencies in African agricultural research.

detailed understanding of the existing pattern of investments and the institutional context within which research funds are raised, allocated, and spent is an invaluable first step in designing appropriate policy interventions to deal with such policy problems.

INSTITUTIONAL DIFFERENCES

Table 8 presents data on the financing arrangements for agricultural research in 13 African countries. There are substantial differences in the sources of support for government versus semi-public agencies. While government agencies developed in ways that are broadly consistent with the aggregate country data, semi-public agencies receive about 80 percent to 90 percent of their funds from earmarked taxes and own income. Moreover, since the mid-1980s the share of funds for semi-public agencies coming from general taxpayer revenues shrank while there was a noticeable increase in donor-sourced funds being channeled to these agencies.

RESEARCH INTENSITIES

To place agricultural research expenditure aggregates in a more meaningful context, it is common to scale these measures according to the size of the agricultural sector. Various research spending ratios are possible and are presented below.

Table 8—Sources of funding as a percent of total funds available

Source of funding	1986	1987	1988	1989	1990	1991
			(percentage)			
Government research agencies						
Government	57.9	51.5	52.6	51.1	51.4	49.9
Own income	5.3	5.4	6.1	5.5	4.5	4.2
Taxes	0	0	0	0	0	0
Donor	35.5	41.7	39.8	42.5	43.1	45.1
Other	1.3	1.3	1.4	0.9	1.0	0.7
Total	100	100	100	100	100	100
Semi-public research agencies						
Government	11.3	8.5	6.2	7.4	5.8	4.4
Own income	32.1	15.0	17.6	11.3	17.8	17.6
Taxes	50.0	66.6	65.3	59.5	69.1	69.6
Donor	3.9	8.3	9.7	19.4	5.8	7.3
Other	2.8	1.5	1.3	2.4	1.6	1.1
Total	100	100	100	100	100	100
Total research agencies[a]						
Government	55.9	49.6	50.4	49.0	49.0	47.5
Own income	6.5	5.8	6.7	5.8	5.1	4.9
Taxes	2.3	3.5	3.6	3.9	4.0	4.2
Donor	34.0	39.7	37.9	40.3	40.9	42.7
Other	1.4	1.4	1.4	0.9	1.0	0.8
Total	100	100	100	100	100	100

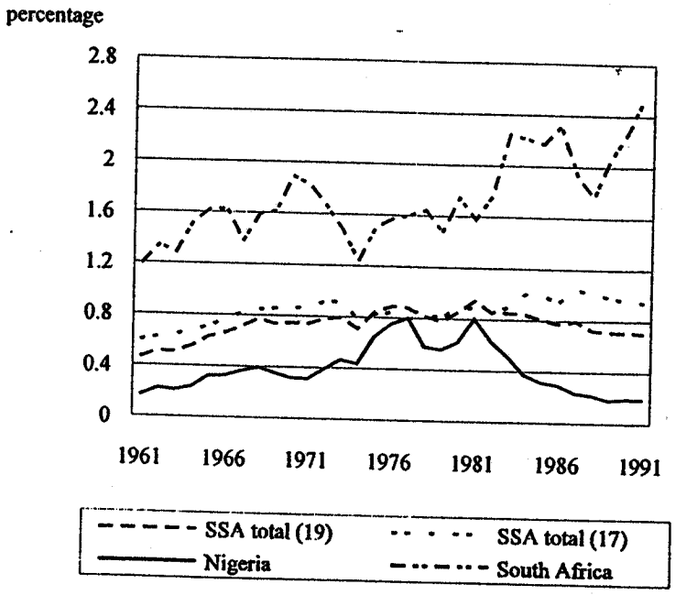
Note: Based on data from Burkina Faso, Cote d'Ivoire, Ghana, Kenya, Madagascar, Malawi, Mali, Niger, Nigeria, Rwanda, Senegal, Zambia and Zimbabwe.
[a] Government plus semi-public research agencies.

Research Spending Intensities

Figure 4 tracks developments in agricultural research expenditures as a percentage of AgGDP for various groupings of African countries. There is no persistent pattern of growth in the overall intensity of research spending. The 19 country average in Figure 4 increased throughout the 1960s and much of the 1970s then declined steadily from a peak in 1981 of 0.93 percent down to 0.69 percent by 1991; below the level of intensity that prevailed 20 years earlier.

This sample average masks some major differences in research intensities among Nigeria, South Africa, and the rest of Africa. South Africa's research intensity ratio trended upward for much of the post-1961 period. At 2.55 percent in 1991 it is significantly higher than many other countries in the region. The instability in the ratio evident from Figure 4 reflects weather-induced fluctuations in agricultural output rather than any significant year-to-year fluctuation in research spending.

Figure 4—*Expenditures as a Percentage of AgGDP, 1961-91*



In contrast to South Africa's persistent upward trend, Nigeria's research intensity ratio grew steadily throughout the 1960s and early 1970s but declined precipitously during the past decade from 0.81 percent in 1981 to a lowly 0.19 percent in 1991. In 1991 research intensity ratios for a 17 country African sample (excluding Nigeria and South Africa) averaged 0.92 percent compared with 0.69 percent for the 19 country sample that includes these systems.

Research intensity ratios for a larger, 24 country sample are available for 1991 (Figure 5). The research spending intensity for this group of countries averaged 0.73 percent in 1991. Six countries spent more than 2 percent of their AgGDP on agricultural research; namely Cape Verde, Botswana, Namibia, South Africa, Zambia, and Swaziland. South Africa and also Mauritius (which have intensity ratios close to 2 percent) have reasonably well-developed research systems even by developed-country standards, hence their comparatively high research intensities. The intensive agricultural research investments in Cape Verde, Swaziland, and Zambia reflect the significant share of donor funds provided to these (relatively small) countries. In the case of Botswana, sizeable domestic support for agricultural R&D comes from substantial government revenues generated by taxing a relatively large and quite prosperous nonagricultural sector.

Government Spending Intensities

Using a political economy framework to account for observed differences in government spending on agricultural R&D, Roe and Pardey (1991) looked at the share of total and agricultural spending by governments earmarked for agricultural R&D.

Figure 5—*Expenditures as a Percentage of Agricultural GDP, 1991*

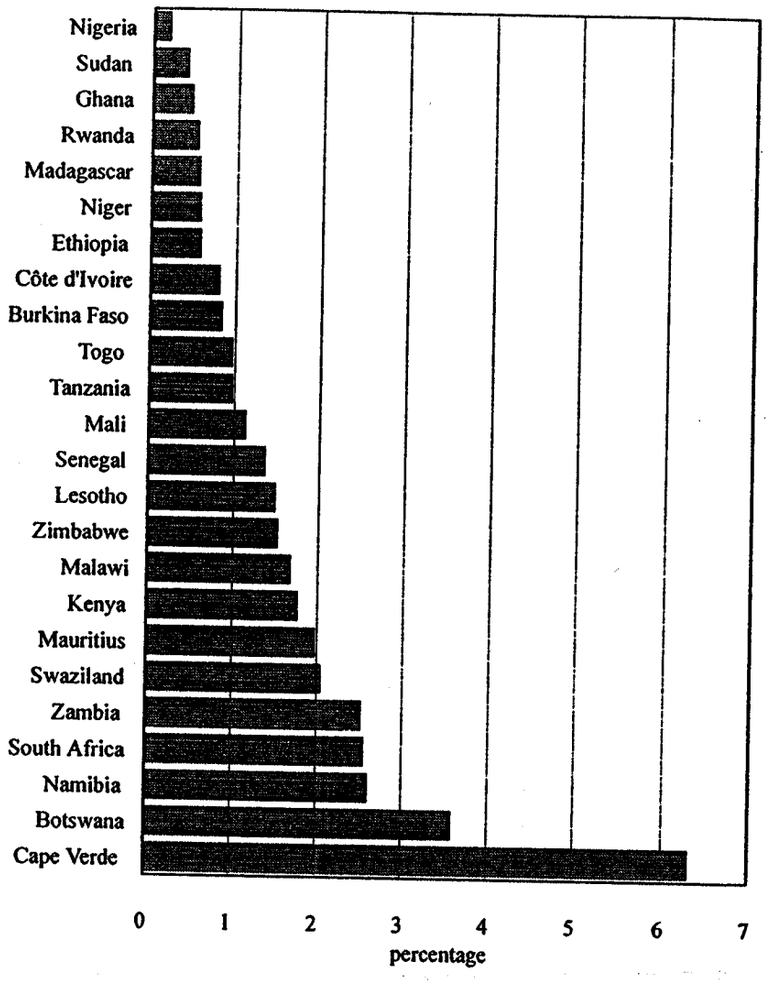


Table 9 presents contemporary government spending shares for various African countries grouped by income level. Data for Nigeria and South Africa have been reported separately and they have been excluded from the respective middle and high income classes whose averages they would dominate.

Whereas the conventional research intensity ratio (i.e., agricultural research spending as a share of agricultural output) in South Africa has been rising and consistently among the highest of all African countries since 1961, agricultural research expenditures have constituted a falling and relatively small share of total government spending. In 1991 South Africa spent only 42 cents per hundred dollars of total government spending on agricultural R&D compared with 59 cents per hundred dollars in 1971 (Table 9). This contrasts with the 16-country average presented in Table 9 whose share of R&D spending relative to total government spending was 2.5 times higher than the corresponding South African spending ratio. Aside from the exceptional case of Nigeria, poorer African countries nowadays commit much more of their public-sector resources to agricultural R&D than Africa's richer countries. However, both Table 9 and Figure 6 show that governments in poorer and richer African countries alike are giving less priority to agricultural R&D in 1991 than 1971.

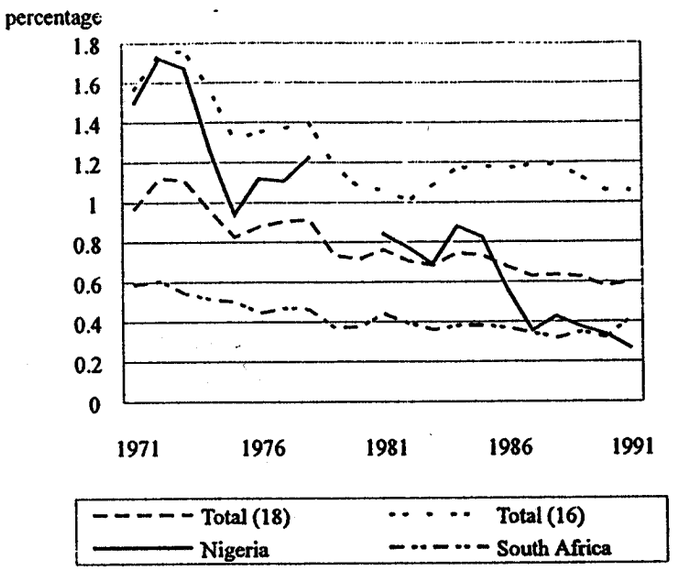
Table 9—Agricultural research expenditures as a percentage of government expenditures

Category	1971	1981	1991
		(percentage)	
Low income (7)[a]	1.14	0.88	1.14
Middle income (5)	1.91	1.16	1.13
High income (4)	1.57	1.16	0.58
Subtotal (16)	1.57	1.06	1.06
Nigeria	1.50	0.84	0.27
South Africa	0.59	0.44	0.42
Total (18)	0.97	0.76	0.60

Note: Income classes were defined as follows: low, less than $750; middle, $750-1500; and high, greater than $1500 of 1991 per capita income measured in terms of 1985 PPP dollars.

[a] Number of countries.

Figure 6—*Research Expenditures as a Percentage of Total Government Expenditures, 1961-91*



Note: Data is missing for Nigeria for 1979 and 1980.

DONOR FUNDING

Funding in the form of loans and grants from international donors accounted for around 34 percent of total expenditures on agricultural research during the early 1980s (Pardey, Roseboom, and Anderson, 1991). As a group (excluding South Africa), African NARSs became increasingly reliant on donor-sourced funds in recent years and this percentage increased to about 43 percent in 1991 -- 49 percent if Nigeria is also excluded (Table 10). Whether this reflects a temporary trend to shore up cash-strapped government research systems in African countries that continue to carry extraordinarily high levels of foreign debt, or a crowding out of alternative, local sources of finance is unclear. Analogous observations were made by Alston and Pardey (1995b) regarding the crowding out of private sources of support by state and federal public funding of agricultural R&D in the United States.

Table 10—Source of funding, 1991

Country	Local	Foreign
	(percentage)	
Botswana	85.5	14.5
Burkina Faso	22.2	77.8
Cape Verde	23.8	76.2
Côte d'Ivoire	53.5	46.5
Ethiopia	55.0	45.0
Ghana	64.1	35.9
Kenya	63.0	37.0
Lesotho	77.1	22.9
Madagascar	41.4	57.0
Malawi	44.6	55.4
Mali	34.0	66.0
Mauritius	90.0	10.0
Namibia	90.0	10.0
Niger	43.3	56.7
Nigeria	94.0	6.0
Rwanda	29.4	70.6
Senegal	35.9	64.1
South Africa	100	0
Sudan	54.5	45.5
Swaziland	78.7	21.3
Tanzania	35.0	65.0
Zambia	20.2	79.8
Zimbabwe	74.2	25.8
Total (23 countries)	66.3	33.7
Total, excl. South Africa	57.5	42.5
Total, excl. South Africa and Nigeria	51.5	48.5

The dependence on donor funding varies markedly among countries. At one extreme is Nigeria which received only 6 percent of its funds from donors during the latter half of the 1980s. Countries as diverse as Burkina Faso, Cape Verde, Mali, Rwanda, Senegal, Tanzania, and Zambia got more than 60 percent of their support from international sources. Data on donor shares for 1991 are presented in Table 10.

Grouping countries in various ways provides different perspectives on the nature of donor support for African agricultural research (Table 11). Per capita income differences definitely matter when accounting for differences in the degree of donor support. The share of donor support is considerably higher in the poorest African countries (62 percent) compared with the richer African countries (2.8 percent, or 14 percent if South Africa is excluded).

Previous analysis, using a much larger sample including NARSs from around the world, showed that developing countries with small populations invest relatively more in agricultural research than developing countries with large populations (Pardey, Roseboom, and Anderson 1991). This partly reflects the disproportionately large amount of donor funds directed to "small" countries when funding is measured on a per capita basis. The data in Table 11, however, do not fully support this earlier finding. One observes the lower intensity of donor support to NARSs in countries with medium compared with large sized populations, which is consistent with the earlier results. But those African countries with relatively small populations receive a much lower intensity of donor support than expected. It may well be that

Table 11—Donor support of African agricultural R&D, 1991.

	Donor share (percentages)
GDP/capita (1991)	
Low income (<$ 750)	62.4
Middle income ($ 750-1500)	31.8
High income (>$ 1500)	2.8
Population (1991)	
Small (<5 million)	20.2
Medium (5-20 million)	53.8
Large (>20 million)	24.3
Former colonialties	
Anglophone	26.3
Francophone	60.7
Other	48.2
Weighted average	33.7

the effects of smallness are offset by the preponderance of relatively rich countries (such as Botswana, Mauritius, and Namibia) with less than five million people in our sample; and as noted, richer African countries receive much lower levels of donor support for R&D than poorer countries.

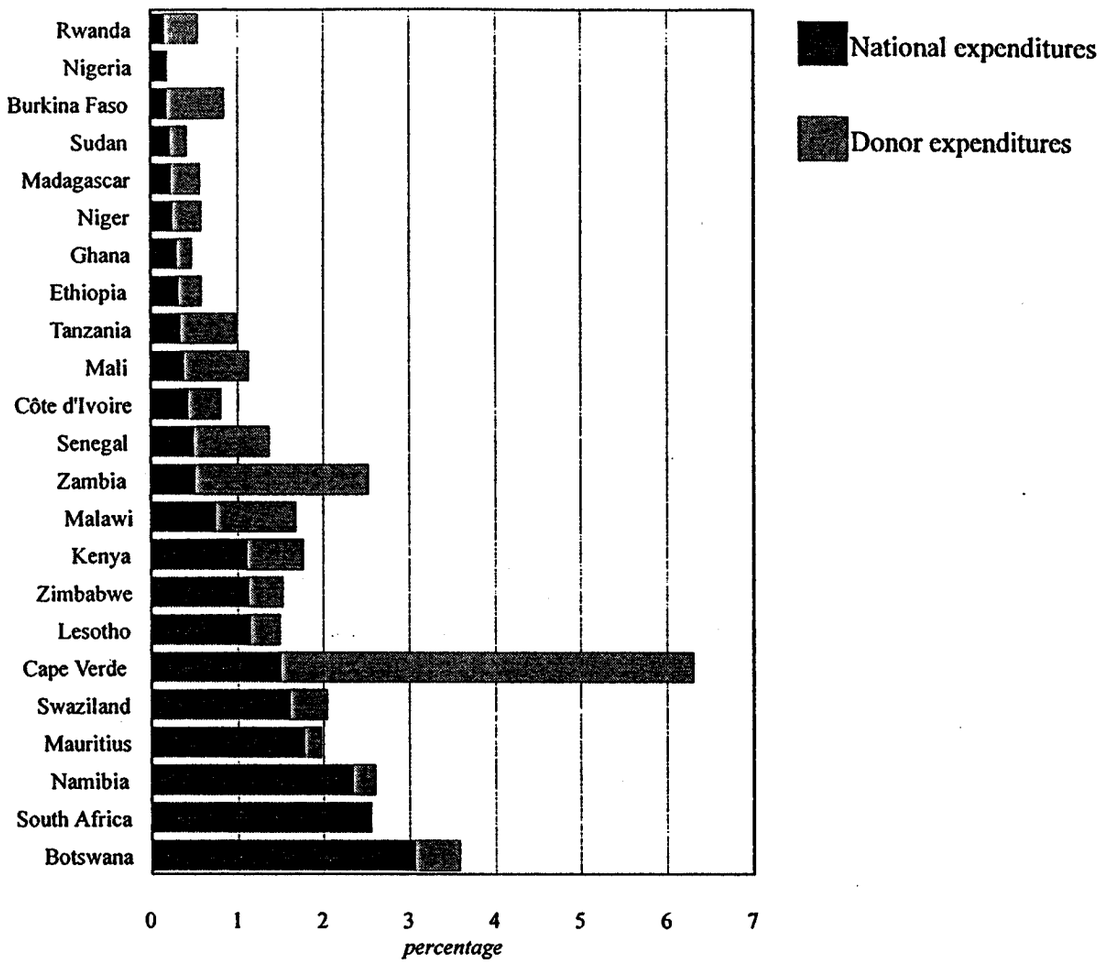
Colonial precedents appear to have persistent influences in terms of the amount of foreign support to agricultural R&D. In 1991, donor funding accounted for 61 percent of total support to the national agricultural research effort in francophone countries and only 26 percent in anglophone countries (36 percent if South Africa is excluded). Part of the difference between francophone and anglophone countries reflects the higher proportion of expatriate researchers working in francophone systems.

Given the substantial but uneven reliance on donor funding for agricultural R&D throughout Africa, Figure 7 presents the research intensity ratios given in Figure 5 but

also decomposes these intensities in terms of the source of funds. If all sources of funds are included, the 23 country sample average is 0.72 cents of research spending per dollar of AgGDP; ranging from a high of 6.3 cents per dollar for Cape Verde to a low of 0.19 research cents per dollar of output for Nigeria. Measuring research spending intensities in terms of spending by governments from *local* sources (i.e., net of international loan and grant funds) changes things considerably. The average spending intensity is lowered by a third from 0.72 cents to 0.48 cents of research spending per dollar of AgGDP. Moreover, the ranking of countries in terms of research intensities based on spending from all sources versus those intensities that include spending from domestic sources only are quite different. Botswana (rather than Cape Verde) invests its own funds more intensively in agricultural R&D than any other country in the sample. At the other end of the spectrum, Burkina Faso, Nigeria, Rwanda, and Sudan spend less than 0.2 percent of their AgGDP on agricultural research from local sources.

The fragile state of many African economies and the large array of demands placed on the public sectors in these countries makes it likely that continued, and in some cases substantial, donor support for research will be necessary for some time to come. However, it is questionable if these extremely high levels of support can

Figure 7—*Expenditures as a Percentage of Agricultural GDP, 1991*



be sustained indefinitely. Certainly serious thought should be given to the appropriate amount to spend on R&D, the design of mechanisms for disbursing donor funds to avoid crowding out domestic sources of support (which may well have been the case over the past few years at least), and the development of means by which funds can be mobilized and deployed to stimulate rather than dissipate the productive potential of the resources committed.

6. CONCLUSION

Sub-Saharan African countries made some progress in developing their agricultural research systems during the past three decades. Particularly the development of research staff has been impressive in terms of numbers (a sixfold increase if South Africa is excluded), Africanization (from roughly 90 percent expatriates in 1961 to 11 percent in 1991), and improvements in education levels (65 percent of the researchers held a postgraduate degree in 1991). The indigenous capacity to train researchers also expanded, although the capacity to train at the M.Sc. and Ph.D. level is still small.

Developments in agricultural research expenditures were considerably less positive. After reasonable growth during the 1960s and early 1970s, growth in expenditures basically stopped in the late 1970s. Although there is considerable variation around this trend, it brings back the notion that many African countries have lost ground with regard to financing their agricultural research. Donor support has clearly increased in importance. Its share in the financing of agricultural research increased from 34 percent in 1986 to 43 percent in 1991. While increased donor support somewhat compensated for declining government funding, it is unlikely that such high levels of support can continue indefinitely.

Many of the developments of the past decade in personnel, expenditures, and sources of support for public-sector R&D in Africa are clearly not sustainable. The rapid buildup of research staff is not paralleled by an equal growth in financial resources. Richer and poorer African countries alike are giving lower priority to spending on agricultural R&D than was the case several decades ago. Spending per scientist has continuously declined during the past 30 years, but most dramatically during the 1980s. And resources are spread increasingly thin over a growing group of researchers, which has negative effects on the efficiency and effectiveness of agricultural research. Turning this around will involve either increased funding for agricultural research or else a painful and, perhaps, wasteful reduction of research staff.

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