INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

sustainable solutions for ending hunger and poverty

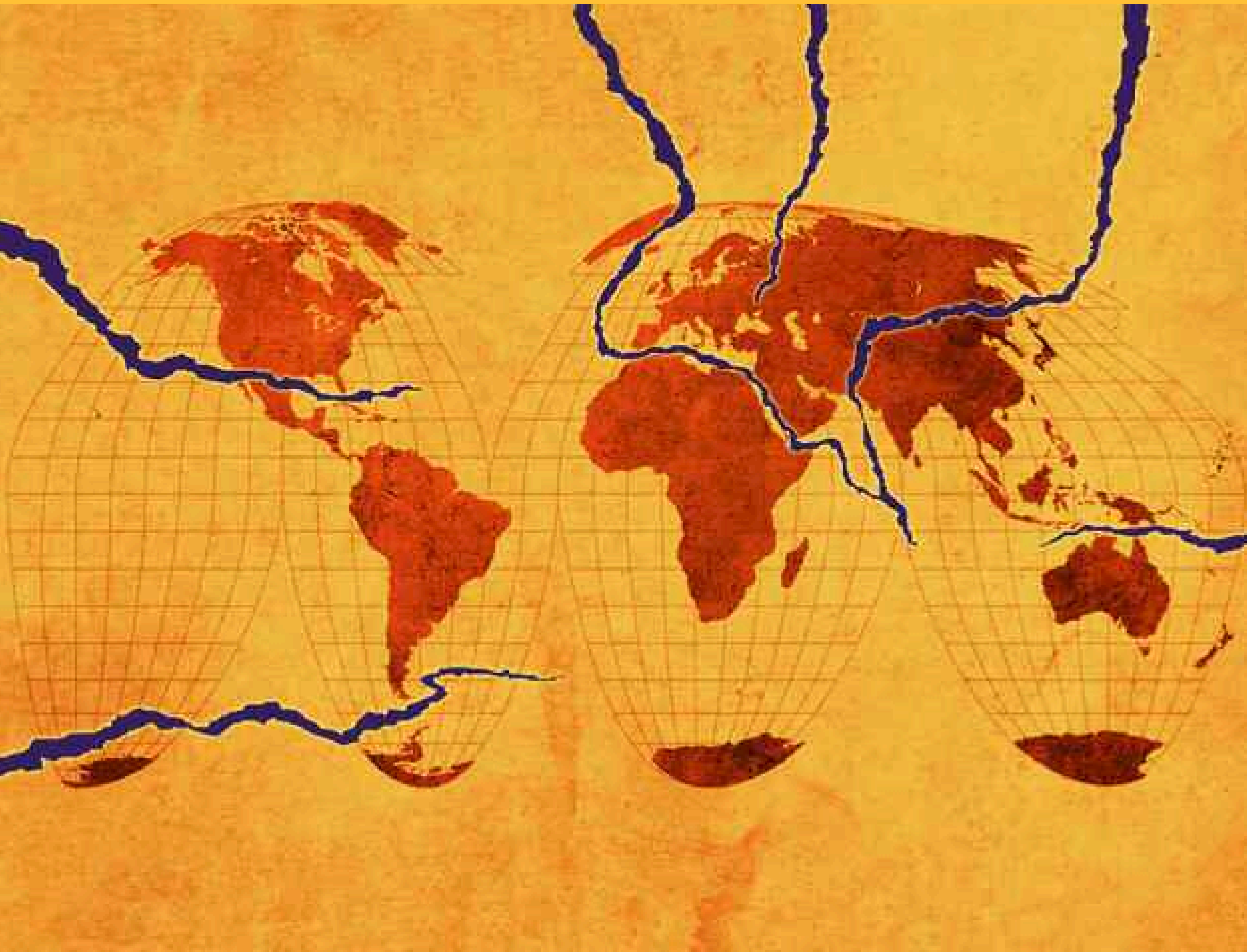
AGRICULTURAL SCIENCE AND TECHNOLOGY INDICATORS

FOOD POLICY REPORT

AGRICULTURAL RESEARCH

A Growing Global Divide?

Philip G. Pardey, Nienke Beintema, Steven Dehmer, and Stanley Wood



THE INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE (IFPRI)

Established 1975

IFPRI's mission is to identify and analyze alternative national and international strategies and policies for meeting the food needs of the developing world on a sustainable basis, with particular emphasis on low-income countries, poor people, and sound management of the natural resource base that supports agriculture; to make the results of its research available to all those in a position to use them; and to help strengthen institutions conducting research and applying research results in developing countries.

While the research effort is geared to the precise objective of contributing to the reduction of hunger and malnutrition, the factors involved are many and wide-ranging, requiring analysis of underlying processes and extending beyond a narrowly defined food sector. The Institute's research program reflects worldwide collaboration with governments and private and public institutions interested in increasing food production and improving the equity of its distribution. Research results are disseminated to policymakers, opinion formers, administrators, policy analysts, researchers, and others concerned with national and international food and agricultural policy.

IFPRI is one of 15 centers that receives its principal funding from 58 governments, private foundations, and international and regional organizations known as the Consultative Group on International Agricultural Research (CGIAR).

AGRICULTURAL SCIENCE AND TECHNOLOGY INDICATORS (ASTI) INITIATIVE

The Agricultural Science and Technology Indicators initiative compiles, processes, and makes available internationally comparable data on institutional developments and investments in agricultural R&D worldwide, and analyzes and reports on these trends in the form of occasional policy digests. The project involves a large amount of original and ongoing survey work focused on developing countries, but also maintains access to relevant data for developed countries. The activities are led jointly by IFPRI and International Service for National Agricultural Research (ISNAR), and involve collaborative alliances with a large number of national and regional R&D agencies, as well as international institutions. The ASTI initiative gratefully acknowledges support from the CGIAR Finance Committee, Australian Centre for International Agricultural Research, the United States Agency for International Development, and the European Commission.

The ASTI data and associated reports are made freely available for research policy formulation and priority setting purposes, and can be found on the ASTI website. http://www.asti.cgiar.org

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Agricultural Research

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Preface

Sustained, well-targeted, and effectively used investments in R&D have reaped handsome rewards from improved agricultural productivity and cheaper, higher quality foods and fibers. As we begin a new millennium, the global patterns of investments in agricultural R&D are changing in ways that may have profound consequences for the structure of agriculture worldwide and the ability of poor people in poor counties to feed themselves.

This report documents and discusses these changing investment patterns, highlighting developments in the public and private sectors. It revises and carries forward to 2000 data that were previously reported in the 2001 IFPRI Food Policy Report *Slow Magic: Agricultural R&D a Century After Mendel.* Some past trends are continuing or have come into sharper focus, while others are moving in new directions not apparent in the previous series. In addition, this report illustrates the use of spatial data to analyze spillover prospects among countries or agroecologies and the targeting of R&D to address specific production problems like drought-induced production risks. More detailed data on the agricultural research investment trends summarized here can be accessed at www.asti.cgiar.org.

Total Science Spending

Throughout the 20th century, improvements in agricultural productivity have considerably alleviated poverty and starvation and fueled economic progress. Further, a large body of evidence closely links productivity improvements to investments in agricultural research and development (R&D).[1] In the past several decades, however, many countries have made major changes in the way they fund and organize public agricultural R&D and the incentives affecting private R&D. These changes are reflected in the shifting patterns of support for agricultural R&D, reported here, raising questions about the prospects for sustaining productivity growth over the next several decades and beyond.

Agricultural R&D is not conducted in isolation from the rest of science.[2] Agricultural scientists have a long history of drawing on and adapting findings from the basic biological, chemical, and other sciences to further their own research, and scientific spillovers have flowed in the other direction as well. Moreover, given contemporary developments, particularly in the genetic and informational sciences, the boundaries between agriculture and other sciences are increasingly becoming blurred. Consequently, putting the agricultural sciences in the context of overall science spending is instructive.

In 2000, $731 billion was invested in *all* the sciences worldwide,[3] including research conducted by both public agencies and private firms. This represented about 1.7 percent of the world's $42.4 trillion gross domestic product (GDP) that year, and an increase of nearly one-third over the inflation-adjusted total of just five years earlier (Table 1). Real spending in all regions of the world

Table 1—Total gross domestic expenditures on research and development, 1995 and 2000

	Total R&D expenditures (million 2000 international dollars)		Share of global total (percent)	
Region/country	**1995**	**2000**	**1995**	**2000**
Developing countries				
Asia–Pacific (26)	52,416	94,950	9.3	13.0
China	19,469	48,247	3.5	6.6
India	11,678	20,749	2.1	2.8
Latin America and the Caribbean (32)	17,222	21,244	3.1	2.9
Brazil	9,771	12,398	1.7	1.7
Sub-Saharan Africa (44)	3,008	3,992	0.5	0.5
Middle East and North Africa (18)	8,626	14,893	1.5	2.0
Other developing countries (21)	19,002	21,895	3.4	3.0
Developing-country subtotal (141)	100,274	156,975	17.9	21.5
High-income countries				
Japan	89,964	99,500	16.0	13.6
United States	196,358	263,043	35.0	36.0
High-income country subtotal (23)	461,367	573,964	82.1	78.5
Total (164)	561,641	730,939	100.0	100.0

SOURCES: Based on Pardey, Dehmer, and El Feki (2006) using data from numerous sources.

NOTES: The number of countries included in the regional totals is shown in parentheses. "Other developing countries" includes many Eastern European, former Soviet countries; "Latin America and the Caribbean" includes Mexico, a member of the Organisation for Economic Co-Operation and Development (OECD); "high-income countries" only includes the high-income members of the OECD—thus excluding a number of high-income countries, such as South Korea and French Polynesia (grouped under Asia–Pacific), Bahrain, Israel, Kuwait, Qatar, and United Arab Emirates (grouped under Middle East and North Africa), and the Bahamas (grouped under Latin America and the Caribbean). All data were first compiled in current local currency units, then deflated to 2000 constant currency units, and finally converted to international dollars using purchasing power parity (PPP) exchange rates.

increased between 1995 and 2000, but growth was uneven.[4] Of the developing countries, the most notable increases were in the Asia–Pacific and Middle East and North Africa regions, with hefty increases of 11.9 and 11.5 percent, respectively (the latter fueled by rapid spending increases in Israel and Turkey). While the overall average rate of growth for developing countries was 8.6 percent per year over the 1995–2000 timeframe, regional averages for developing countries ranged from lows of 1.9 percent per year for the "other developing countries" category (which includes several former Soviet states) and 3.0 percent per year for Sub-Saharan Africa, to notable highs of 19.7 percent per year for China and 12.2 percent per year for India.

These regional trends hide a profoundly disturbing reality—evidence of a large and, in places, growing divide between the scientific haves and have-nots. For example, the overall growth in the Asia–Pacific region masks the fact that just two countries, China and India, accounted for 89 percent of the $42.5 billion increase in regional spending from 1995 to 2000. Put another way, China and India accounted for 59 percent of the region's scientific spending in 1995, jumping to 73 percent of the regional total by 2000. In contrast, while research spending in the seven Pacific countries (including Fiji, French Polynesia, New Caledonia, and others) grew by as much as 9.4 percent annually from 1995, this was from an exceptionally small base, so their $120.7 million total in 2000 represents just a minuscule 0.13 percent of the Asia–Pacific region's total science spending.

Although geographically large and home to over 10 percent of the world's population, Sub-Saharan Africa accounts for just 0.5 percent of the world's gross investment in science. Further, South Africa, with less than 7 percent of this region's population, accounts for about two-thirds of the regional total for gross domestic expenditures on R&D. While 39 of the 44 countries in Sub-Saharan Africa for which data are available increased their investments in R&D between 1995 and 2000, South Africa accounted for about 61 percent of the nearly $1 billion increase.

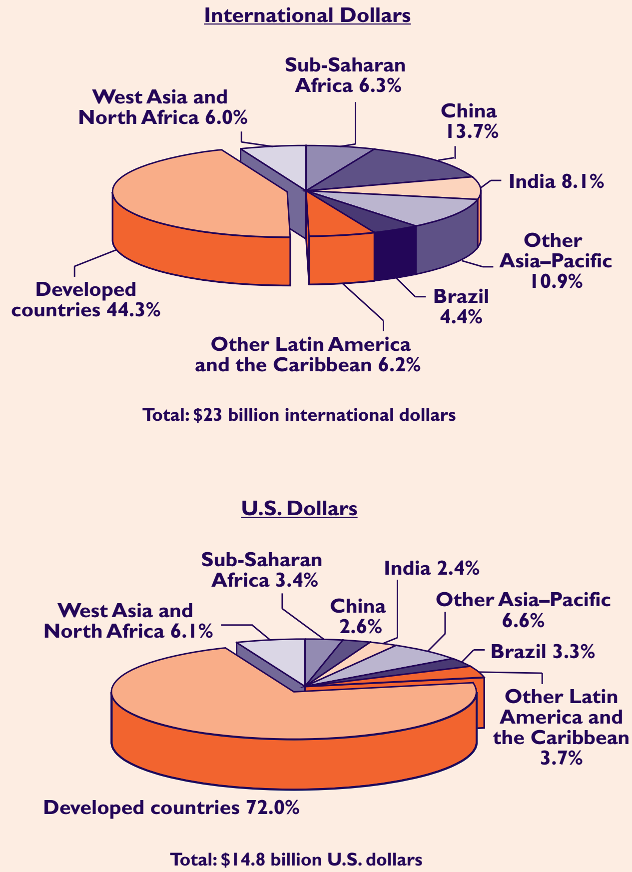
Middle East and North Africa fared a bit better than Sub-Saharan Africa, with a real increase of R&D investment of almost 73 percent between 1995 and 2000. Indeed, the only country tracked in this region that reported a decrease in investment was Kuwait, with a period decline of almost 34 percent. As in Sub-Saharan Africa, however, the growth is highly concentrated, with Israel and Turkey alone accounting for almost 79 percent of the region's increase during this period.

The bifurcation in science spending is widespread, and these new data make the significant geopolitical concentration of science spending worldwide manifestly clear. In 2000, the top five countries (in descending order, the United States, Japan, Germany, France, and the United Kingdom) accounted for 68.6 percent of the world's total science spending, and the two top spending countries alone (the United States and Japan) accounted for 63 percent of the total for Organisation for Economic Co-Operation and Development (OECD) countries.[5] Expanding this group to the top 10 countries—which includes Italy, Canada, the lower income but fast-growing countries China and India, and South Korea—the share comes in at 81.6 percent of the world total. Moreover, the share of the bottom 80 countries (accounting for 11.1 percent of the world's population in 2000 but only 2.4 percent of global GDP) slipped from 0.29 percent of the global total in 1995 to 0.26 percent in 2000. Put together, this is evidence of a large and sustained, if not growing, gap between a comparatively small group of scientific haves and a substantial group of scientific have-nots.

Box 1

INTERNATIONALLY COMPARABLE MEASURES OF R&D

Figure B1 Agricultural research spending in U.S. versus international dollars, 2000



SOURCE: Calculated by authors based on data reported in Table 2.

Cross-country comparisons of R&D expenditures, like most international comparisons of economic activity more generally, are confounded by substantial differences in price levels among countries. This is particularly a problem when valuing something like expenditures on agricultural R&D, where typically two-thirds of the expenditures are on local scientists and support staff, not capital or other goods and services that are commonly traded internationally. For example, the average salary received by full professors working at large public universities in the United States (net of benefits) was $88,457 in 2004/05. A comparable annual salary paid to a chief scientific officer in Bangladesh working for the national government's main agricultural research agency was TK 20,700 (equivalent to 1,683 international dollars when converted using purchasing power parities [PPPs] or only US$316 when converted using official exchange rates), while a mid-career senior scientist working for Embrapa, Brazil, earned an average of 72,348 reals (65,705 international dollars or US$30,020).

Converting research expenditures from different countries to a single currency using official exchange rates tends to understate the quantity of research resources used in economies with relatively low prices, while overstating the quantity of resources used in countries with high prices.[a] At present, there is no entirely satisfactory method for comparing consumption or expenditures among countries at different points in time (or for that matter, at the same point in time). Unfortunately, the choice of deflator and currency converter can have substantial consequences for both the measure obtained and its interpretation.

Most of the research expenditures in this report are denominated in 2000 "international dollars" using PPPs to do the currency conversions.[b] For convenience of interpretation, the reference currency—here an international dollar—is set equal to a U.S. dollar in the benchmark year.

Figure B1 contrasts the regional expenditure shares both for public agricultural research expenditures using PPPs versus official exchange rates to do the currency conversion. The left-hand side of the figure denotes 2000 research spending in international dollars obtained using PPPs, while the right-hand side of the figure reports the U.S. dollar estimates obtained using the same underlying R&D data together with official exchange rates. Taking the PPP estimates to be more representative of the amount of resources committed to research, the U.S. dollar estimates overstate the share of developed-country agricultural research in the global total and grossly understate the African, Chinese, and other Asia–Pacific shares.

SOURCES: Pardey, Roseboom, Craig 1992; World Bank 2005b.

[a]*A country's international price level is the ratio of its PPP rate to its official currency exchange rate for U.S. dollars. In other words, the international price level is an index of the costs of goods in one country at the current rate of exchange relative to the costs of the same bundle of goods in a numeraire country, in this case the United States. For example, in 2000 the ratio of PPP to exchange rate for Australia was 0.77, indicating that average prices in Australia were 23 percent lower than they were in the United States. The corresponding ratio for Bangladesh was 0.22, meaning that a bundle of goods and services purchased for $100 in the United States cost only $22 dollars in Bangladesh.*

[b]*We use a procedure described by Pardey, Roseboom, and Craig (1992) that first deflates research expenditures expressed in current local currency units to a base year set of prices (2000, in this case) using a local price deflator and then converts to a common currency unit (specifically, international dollars) using PPPs for 2000 obtained from the World Bank (2005b) rather than the more familiar official exchange rates.*

Public Agricultural R&D

Research Spending Trends

Worldwide, public investments in agricultural research increased by 51 percent in inflation-adjusted terms over the past two decades, from an estimated $15.2 billion (2000 international dollars) in 1981 to $23.0 billion in 2000 (Table 2). These data reveal a significant structural shift: during the 1990s, developing countries as a group undertook more of the world's public agricultural research than the developed countries.[6] The Asia–Pacific region has continued to gain ground, accounting for an ever-larger share of the developing-country total since 1981. Just two countries from this region, China and India, accounted for 39.1 percent of the developing world's expenditure on agricultural R&D in 2000, a substantial increase from their 22.9 percent combined share in 1981. In stark contrast, Sub-Saharan Africa has continued to lose market share, falling from 17.3 to 11.4 percent of the developing-world total between 1981 and 2000.

Paralleling spending patterns for all the sciences, agricultural R&D has become increasingly concentrated in a handful of countries worldwide. Just four countries—the United States, Japan, France, and Germany—accounted for two-thirds of the public research done by rich countries in 2000, about the same as two decades before. Similarly, just five developing countries—China, India, Brazil, Thailand, and South Africa—undertook 53.3 percent of the developing world's public agricultural research in 2000, up from 40

Table 2—Total public agricultural research expenditures by region, 1981, 1991, and 2000

	Agricultural R&D spending (million 2000 international dollars)			Share of global total (percent)		
Region/country	**1981**	**1991**	**2000**	**1981**	**1991**	**2000**
Developing countries						
Asia–Pacific (28)	3,047	4,847	7,523	20.0	24.2	32.7
China	1,049	1,733	3,150	6.9	8.7	13.7
India	533	1,004	1,858	3.5	5.0	8.1
Latin America and the Caribbean (27)	1,897	2,107	2,454	12.5	10.5	10.7
Brazil	690	1,000	1,020	4.5	5.0	4.4
Sub-Saharan Africa (44)	1,196	1,365	1,461	7.9	6.8	6.3
Middle East and North Africa (18)	764	1,139	1,382	5.0	5.7	6.0
Developing-country subtotal (117)	6,904	9,459	12,819	45.4	47.3	55.7
High-income countries						
Japan	1,832	2,182	1,658	12.1	10.9	7.2
United States	2,533	3,216	3,828	16.7	16.1	16.6
High-income country subtotal (22)	8,293	10,534	10,191	54.6	52.7	44.3
Total (139)	15,197	19,992	23,010	100.0	100.0	100.0

SOURCES: Calculated by authors based on Agricultural Science and Technology Indicators (ASTI) initiative data; Pardey and Beintema (2001); RICYT (2005); Casas, Solh, and Hafez (1999); OECD (2005); Eurostat (2005); and USDA/CRIS (2006).

NOTES: The number of countries included in the regional totals is shown in parentheses. See notes to Table 1 regarding country aggregation/groupings. These estimates exclude Eastern Europe and former Soviet Union countries. Regional totals were scaled up from national spending estimates for countries that represented 79 percent of the reported Sub-Saharan African total, 89 percent of the Asia–Pacific total, 86 percent of the Latin America and Caribbean total, 57 percent of the Middle East and North Africa total, and 84 percent of the high-income country total.

Table 3—Spatial concentration of public expenditures in agricultural R&D worldwide, 1995 and 2000

Country grouping	1995 (percent)	2000 (percent)	2000–02 (percent)					
			GDP	Population	Agricultural land	Agricultural production		
						Crops	Livestock	Total
Top 5	47.5	50.0	52.6	51.8	22.7	38.6	42.8	40.4
Top 10	61.7	62.4	66.5	56.1	33.2	52.8	54.2	53.4
Bottom 80	8.6	6.3	5.7	11.3	13.6	7.1	3.9	5.8

SOURCES: Calculated by authors based on Agricultural Science and Technology Indicators (ASTI) initiative data and World Bank (2006).

NOTES: The top 10 agricultural R&D expenditure countries in 1995 (in descending order) were United States, Japan, China, India, Brazil, Germany, South Korea, Australia, United Kingdom, and France; the top 10 countries in 2000 (in descending order) were United States, China, India, Japan, Brazil, Germany, Australia, South Korea, United Kingdom, and Canada. GDP and population data are from 2000; agricultural production and land area data are from 2002.

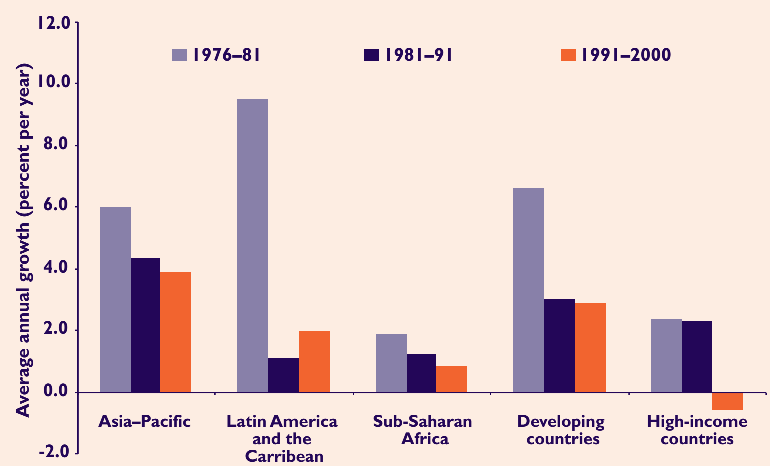
percent in 1981.[7] Meanwhile, only 6.3 percent of agricultural R&D worldwide was conducted in 80 (mainly low-income) countries—home to some 625 million people in 2000 and accounting for nearly 14 percent of the world's agricultural land area. Notably, this 80-country share of global agricultural R&D spending is slightly more than their corresponding value share (5.8 percent) of worldwide agricultural output (Table 3).

A shifting and widely disbursed pattern of growth is evident among regions (Figure 1). Certainly, the more recent rates of increase in inflation-adjusted spending for all developing regions of the world failed to match the rapid ramping up of public agricultural R&D spending of the 1970s (Pardey and Beintema 2001). The growth in spending for the Asia–Pacific region held strong, averaging 4.3 percent per year in the 1980s and 3.9 percent per year in the decade to follow. Growth in China and India picked up in the late 1990s, in both instances reflecting government policies to revitalize public research and improve its commercialization prospects—including linkages with the private sector.[8] Spending growth throughout the Latin American region as whole was more robust during the 1990s than the 1980s, although the recovery was more fragile and less certain for some countries in the region (such as Brazil, where rates of spending contracted at the close of the 1990s, then partially recovered in 2000/01).

Overall investments in agricultural R&D in Sub-Saharan Africa failed to grow by more than 1 percent per year during the 1990s—the continuation of a longer run slowdown. Even more disturbing, about half of the 27 African countries for which national estimates were available spent less on agricultural R&D in 2000 than they did in 1991 (Beintema and Stads 2004).

A notable feature of the growth trends is the contraction in support for public agricultural R&D among rich countries (Figure 1). During the 1980s, real public agricultural R&D spending grew by an average of 2.3 percent per year for the rich countries compared with an average rate of decline of 0.6 percent per year during the 1990s. While spending in the United States picked up in the second half of the 1990s (2.9 percent per year for 1995–2000 versus 1.5 percent per year for 1990–95), a massive reduction in public research funding

Figure 1 Public agricultural R&D spending trends



SOURCE: Table 2.

NOTE: Inflation-adjusted growth rates were calculated as weighted regional averages, using the least-squares method described in World Bank (2006, 305).