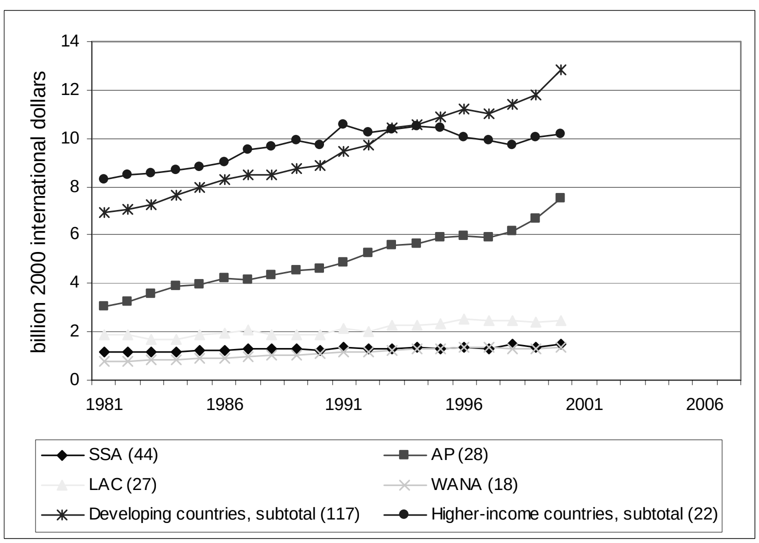
Global Chapter 8 Tables and Figures

Table 8.1 Total public agricultural research expenditures by region, 1981, 1991, and 2000. Source: Pardey et al., 2006a based on Agricultural Science and Technology Indicators (ASTI) data at www.asti.cgiar.org and various other data sources.

	Agricultural R&D spending			Shares in global total		
	1981	1991	2000	1981	1991	2000
	(*million 2000 international dollars*)			(*percentage*)		
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 & 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
West Asia & North Africa (18)	764	1,139	1,382	5.0	5.7	6.0
Developing countries, subtotal (117)	*6,904*	*9,459*	*12,819*	*45.4*	*47.3*	*55.7*
Japan	1,832	2,182	1,658	12.1	10.9	7.2
USA	2,533	3,216	3,828	16.7	16.1	16.6
Subtotal, higher income countries (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**

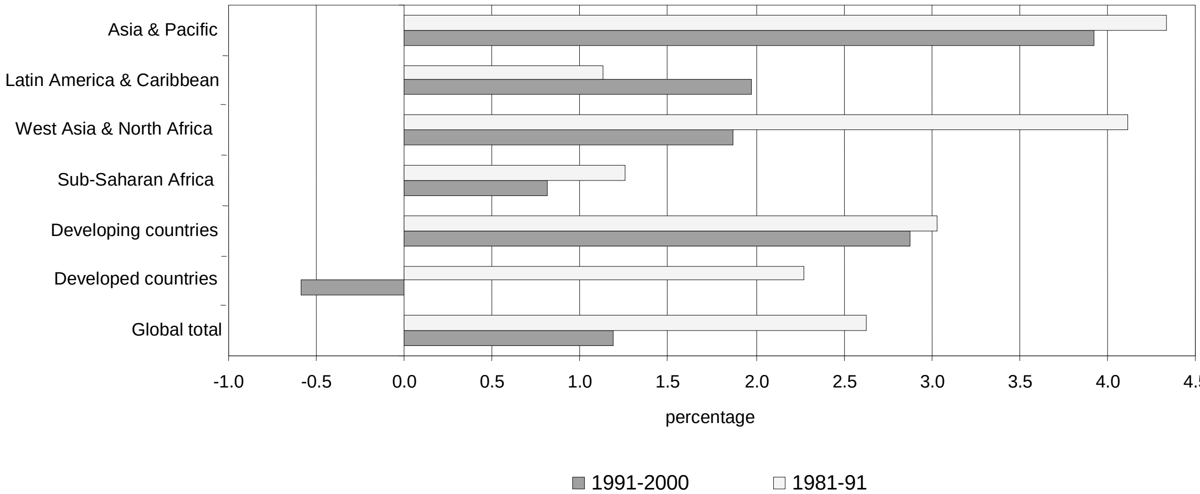
Notes: The number of countries included in regional totals is shown in parentheses. These estimates exclude East Europe and former Soviet Union countries. The high income countries total excludes a number of high income countries such as South Korea and French Polynesia (which has been grouped in the Asia and Pacific total), Bahrain, Israel, Kuwait, Qatar, and United Arab Emirates (grouped in West Asia and North Africa), and Bahamas (Latin America and Caribbean). To form these regional totals we scaled up national spending estimates for countries that represented 79% of the reported sub-Saharan African total, 89% of the Asia and Pacific total, 86% of the Latin America and Caribbean total, 57% of the West Asia and North Africa total, and 84% of the high-income total.

Figure 8.1 Total public agricultural research expenditures by region, 1981-2000. Source: See Table 8.1.



Notes: See Table 8.1

Figure 8.2 Growth rates of public agricultural R&D spending. Source: See Table 8.1.



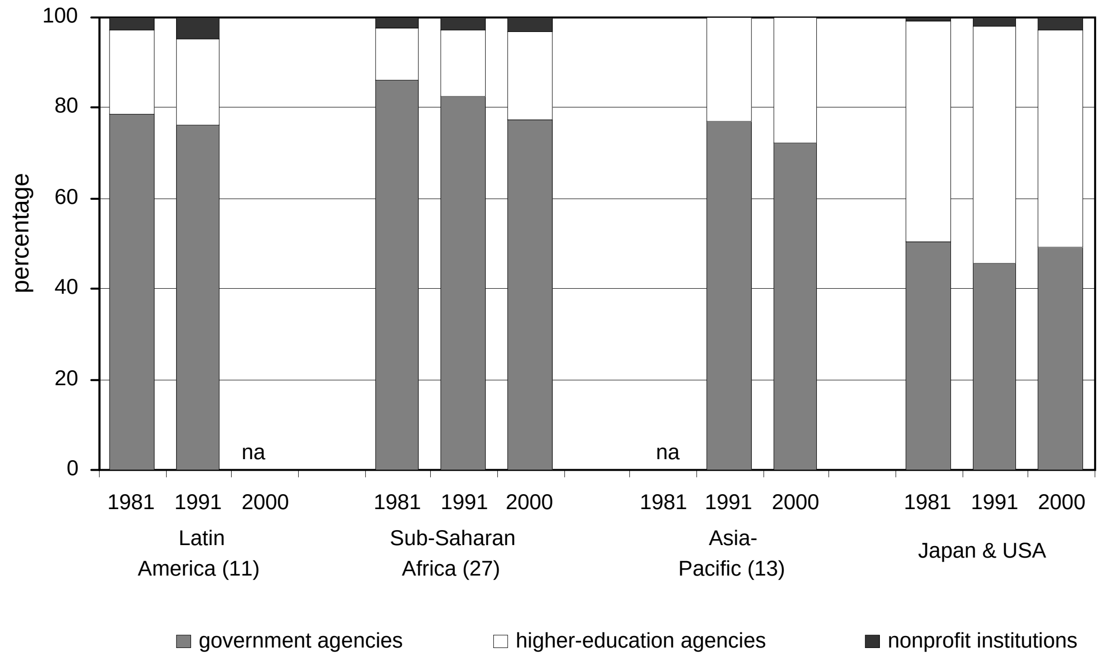
Notes: See Table 8.1. Annual growth rates were calculated using the least-squares regression method, which takes into account all observations in a period. This results in growth rates that reflect general trends that are not disproportionately influenced by exceptional values, especially at the end point of the period.

Table 8.2 Commodity focus by main research area, various years. Source: ASTI database, 2007.

	Asia-Pacific (10), 2002/03	Sub-Saharan Africa (26), 2000/01	Latin America (9), 1996	Total developing countries (45)
Major commodity area		(*percentage*)		
Crops	52.5	48.1	53.5	52.1
Livestock	13.2	17.8	17.9	14.7
Forestry	6.5	6.1	4.8	6.2
Fisheries	5.8	4.8	4.3	5.4
Post-harvest	3.6	6.5	3.9	4.1
Natural Resources	8.6	7.1	8.8	8.4
Other	9.8	9.5	6.7	9.2
Major crops				
Wheat	6.2	4.9	4.3	5.7
Rice	18.0	7.6	6.1	14.4
Maize	5.4	8.0	13.8	7.3
Cassava	0.6	5.8	2.2	1.6
Vegetables	9.4	9.0	18.6	11.0
Fruits	11.7	11.0	17.4	12.7
Sugarcane	5.0	4.9	3.7	4.7
Coffee	0.6	3.0	6.3	2.0
Other	43.3	45.7	27.4	40.7

Note: Shares based on allocation of full-time equivalent researchers.

Figure 8.3 Institutional orientation of public agricultural R&D, 1981, 1991, 2000. Source: Pardey et al. (2006a) based on ASTI data.



Note: The number of countries included in regional totals is shown in parentheses. The reported shares for Japan and the United States may understate the role of nonprofit institutions. n.a. indicates not available.

BOX 8.1 Plant breeding and biotechnology research

a. Trends in multinational plant and biotech research

One of the most rapidly growing areas of private sector agricultural research has been the plant biotech area. This research started in the 1970s, increased very rapidly in the late 1980s and 1990s to over a billion dollars of research in response to the technological opportunities offered by the breakthroughs of cellular and molecular biology and also due to stronger intellectual property rights particularly in the US. Some of this change was due to companies shifting research resources from chemical research to biological research.

Since 1999, several of the six largest biotech firms, which dominate private biotech research worldwide, have reduced their agricultural biotechnology research, and in the aggregate agricultural biotechnology research expenditures probably stagnated. Monsanto reduced its research expenditure, which is about 85% agricultural biotechnology and plant breeding, from US$588 million in 2000 to US$510 million in 2003 before increasing back to $588 million in 2005. Syngenta's plant science R&D expenditures declined from $161 million in 2000 to $109 million in 2003 and to $100 million in 2005 (Syngenta, 2006). In contrast Bayer and BASF seem to be increasing their investments in biotech. Bayer purchased Aventis Crops Sciences, which had a major biotech research program, in 2001. Bayer has made a substantial investment in Agricultural biotech R&D since then and now spends about $80 million on seed and biotech research expenses (Garthof, 2005). BASF spent approximately $82 million in 2004 (Garthof, 2005). They recently (2006) acquired the Belgium biotech firm CropDesign and have committed themselves to spending $320 million on biotech research over the new three years (Nutra Ingredients, 2006).

Public-sector investment in agricultural biotech growing rapidly in some large developing countries

Despite the controversy about transgenic crops and generally sluggish investments in biotechnology, government investments in agricultural biotechnology research and development are growing rapidly in some large developing countries. The most dramatic growth in public biotech investments is in China from under 300 million yuan in 1995 to over 1.6 billion yuan in 2003 (equivalent to US$ 200 million). This 1.3 billion yuan increase accounts for between 25 to 33% of the increase in all agricultural research in the same time period (Huang 2005). In addition Chinese cities and provinces have announced major government programs to commercialize the results of public sector biotech research such as the new center in Beijing which will invest US$160 million over the next three years to nurture 100 companies and 500 labs (Science 2006).

National governments in Brazil, Malaysia, and South Africa are also making major investments in agricultural biotech research and some provincial governments such as Sao Paolo in Brazil and Andhra Pradesh in India are also making substantial investments. In July 2006 the Brazilian government announced that it would invest US $3.3 billion over the next 10 years to develop biotechnology for health, industry, and agriculture (checkbiotech.org). Malaysia announced that it would invest US $3.12 billion in agriculture in the next plan period and that agricultural biotechnology would play a major role (Government of Malaysia 2006). Indian officials said in the spring of 2006 that it will invest US$100 million and the US will add US$24 million on agricultural biotechnology in India (Jayaraman, 2006). South Africa launched Plantbio (www.plantbio.org.za) in late 2004 to support the commercialization of plant biotech products.

Table 8.3 Estimated public and private agricultural R&D investments, 2000. Source: Pardey et al. (2006a) based on ASTI data.

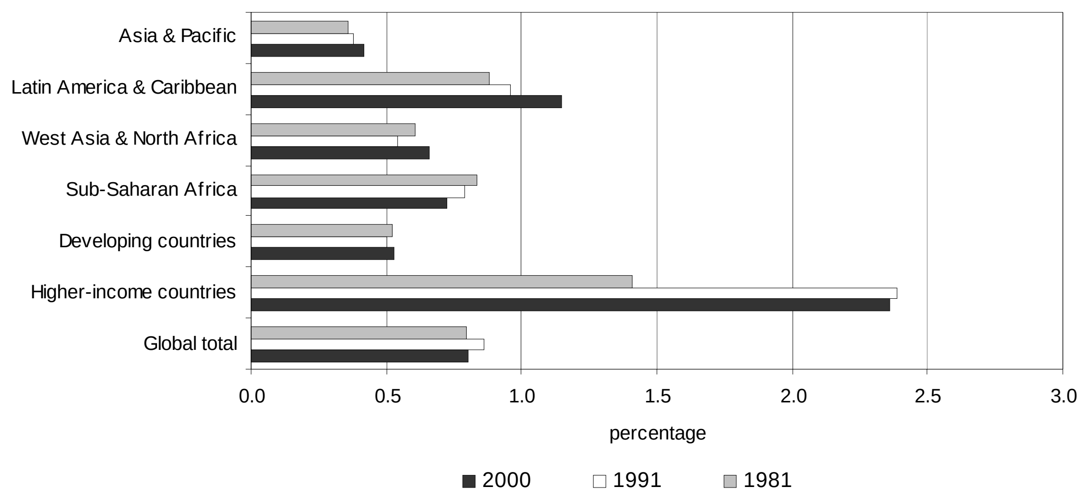
	Expenditures			Shares	
	Public	Private	Total	Public	Private
	(*millions 2000 intl. dollars*)			(*percentage*)	
Asia & Pacific	7,523	663	8,186	91.9	8.1
Latin America & Caribbean	2,454	124	2,578	95.2	4.8
Sub-Saharan Africa	1,461	26	1,486	98.3	1.7
West Asia & North Africa	1,382	50	1,432	96.5	3.5
Developing countries, subtotal	12,819	862	13,682	93.7	6.3
Higher-income countries, subtotal	10,191	12,086	22,277	45.7	54.3
Total	**23,010**	**12,948**	**35,958**	**64.0**	**36.0**

Table 8.4 Total S&T spending by region and shares agriculture in total, 2000. Source: Calculated from Table 8.1 and Pardey et al., 2006a.

	S&T spending	Shares in global total S&T spending	Agricultural R&D as a share of total S&T spending
	(million 2000 international dollars)	*(percentage)*	
Asia & Pacific (26)	94,950	13.4	8.6
Latin America & Caribbean (32)	21,244	3.0	12.1
Sub-Saharan Africa (44)	3,992	0.6	37.2
West Asia & North Africa (18)	14,893	2.1	9.6
Developing countries, subtotal (120)	135,079	19.1	10.1
Higher income countries (23)	573,964	80.9	3.9
Total (143)	**709,043**	**100**	**5.1**

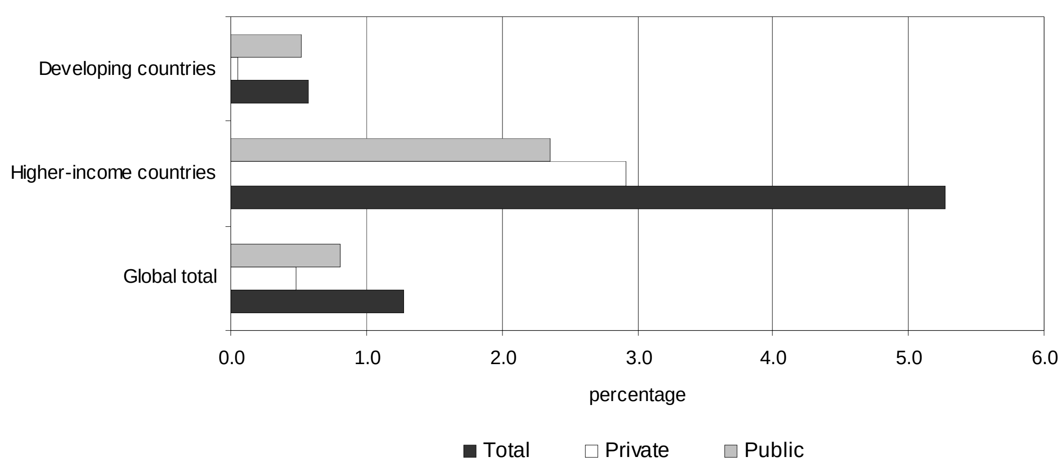
Notes: These estimates exclude East Europe and former Soviet Union countries. The number of countries included in regional totals is shown in parentheses. Regional sample sizes are slightly different from those in Table 8.1.

Figure 8.4 Intensity of public agricultural R&D investments over agricultural output. Source: Pardey et al. (2006a) based on ASTI data.



Note: The intensity ratios measure total public agricultural R&D spending as a percentage of agricultural GDP.

Figure 8.5 Public, private and total agricultural research intensities, 2000. Source: Pardey et al. (2006a) based on ASTI data.



Note: The intensity ratios measure total public and private agricultural R&D spending as a percentage of agricultural GDP.

Table 8.5 Other intensity ratios, 1981, 1991 and 2000. Source: Pardey et al. (2006a) based on ASTI data.

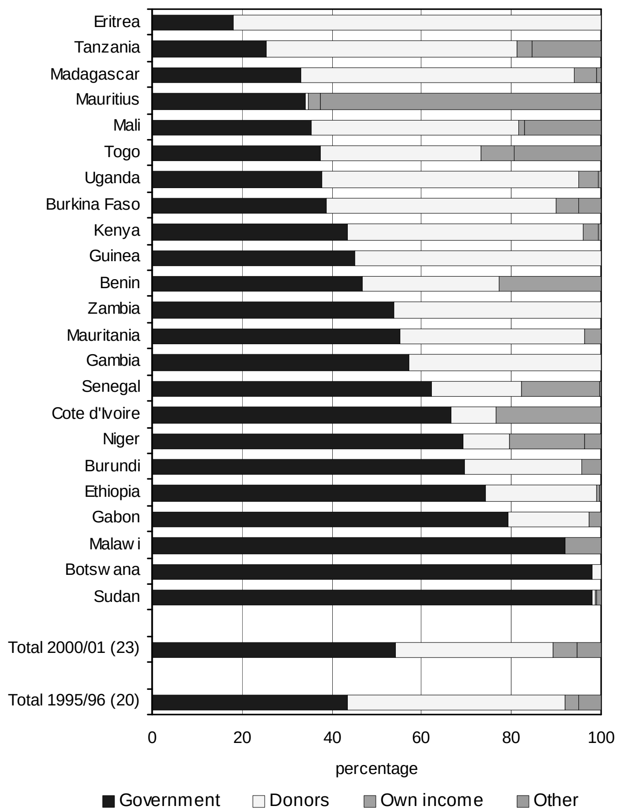
	Public agricultural R&D spending					
	Per capita			Per capita of economically active agricultural population		
	1981	1991	2000	1981	1991	2000
	(*2000 international dollars*)					
Asia & Pacific	1.31	1.73	2.35	3.84	5.23	7.57
Latin America & Caribbean	5.43	4.94	4.96	45.10	50.54	60.11
Sub-Saharan Africa	3.14	2.69	2.28	9.79	9.04	8.22
West Asia & North Africa	3.24	3.63	3.66	19.15	27.30	30.24
Developing countries, subtotal	*2.09*	*2.34*	*2.72*	*6.91*	*8.14*	*10.19*
HIhger-income countries, subtotal	10.91	13.04	11.92	316.52	528.30	691.63
Total	*3.75*	*4.12*	*4.13*	*14.83*	*16.92*	*18.08*

Table 8.6 Aid to agriculture, 1970–2004. Source: Pardey et al., 2006a.

Year	Total official development assistance (ODA)	Bilateral aid	
		Amount	Share to agriculture
	(*million 2000 U.S. dollars*)		(*percentage*)
1970	24,719	20,886	4.91
1975	35,448	26,233	11.13
1980	49,166	31,875	16.63
1985	41,773	30,782	15.93
1990	67,071	47,540	11.39
1995	64,077	44,129	9.82
2000	53,749	36,064	6.36
2003	65,502	47,222	4.22
2004	74,483[a]	50,700[a]	na

Note: na indicates not available.
[a] Preliminary estimate

Figure 8.6 Country-level sources of funding in sub-Saharan Africa, 1995/96 and 2000. Source: Beintema and Stads, 2006.



Notes : Figure includes only funding data from the main agricultural research agencies in each of the respective countries. Combined, these agencies accounted for 76% of total spending for the 23-country sample in 2000. Data for West Africa, with the exception of Nigeria, are for 2001.

Figure 8.7 Comprehensive impact assessment framework for R&D investment. Source: Adopted and modified from Shrestha and Bell, 2002.

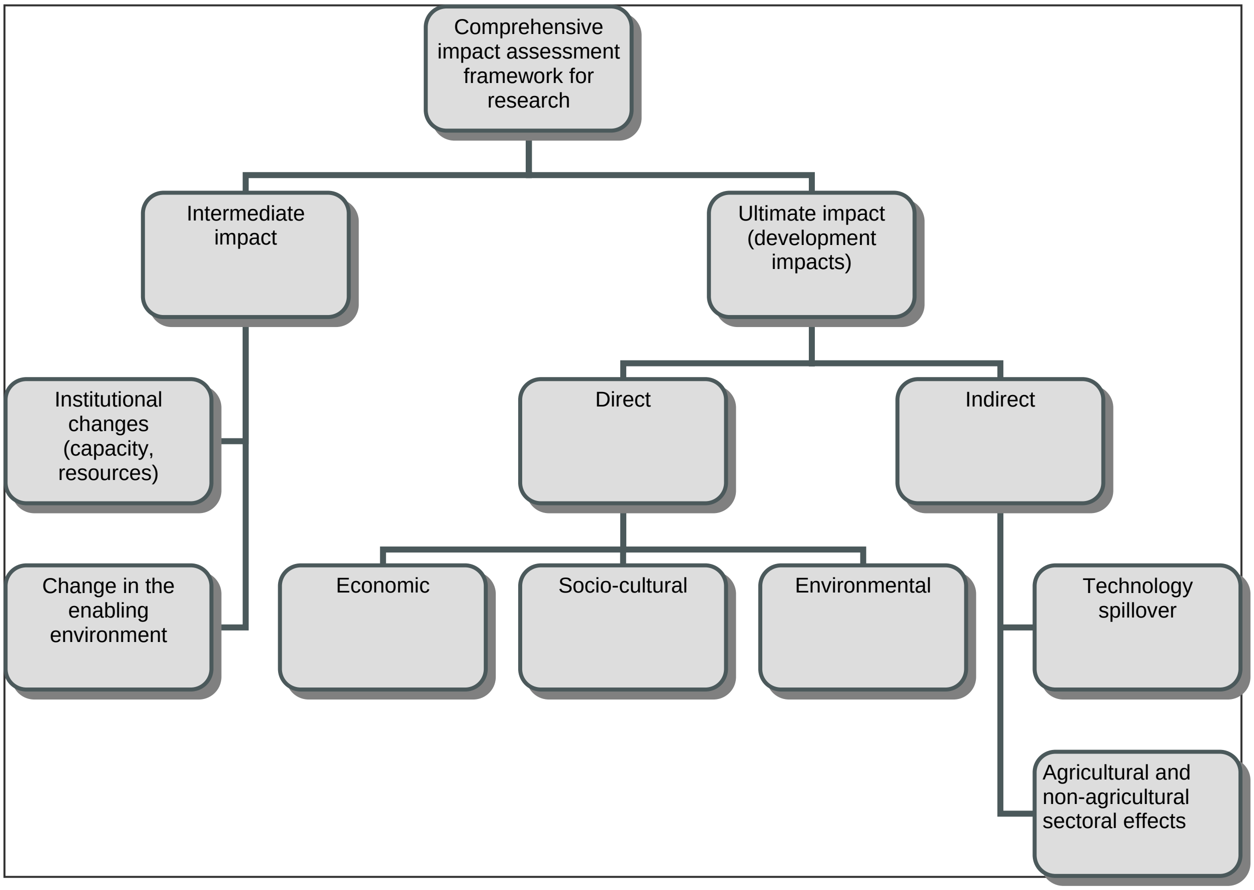


Table 8.7 Comparison of ROR for national agricultural R&D expenditure across sub-regions. Source: Thirtle et al., 2001.

Sub-regions	Countries	Mean ROR (%)	Weighted mean ROR (%)	Countries with negative ROR
Africa	Algeria, Botswana, Ethiopia, Cote d'Ivoire, Ghana, Guinea-Bissau, Kenya, Lesotho, Mauritania, Morocco, Rwanda, Senegal, Tanzania, Tunisia, Uganda, Zambia, and Zimbabwe.	18	22	Lesotho, Senegal, and Tanzania.
Asia	Bangladesh, China, India, Indonesia, Jordan, Malaysia, Nepal, Pakistan, Philippines, Sri-Lanka, Thailand.	23	26	Sri-Lanka
Latin America	Bolivia, Brazil, Chile, Colombia, Costa-Rica, Dominican Rep., Guatemala, Honduras, Jamaica, Mexico, Panama, Peru, Venezuela.	10	-6	Brazil, Dominican Republic, Jamaica, Mexico, Panama, Peru, Venezuela.

Table 8.8 Costs-benefits and internal rate of return for NARS and IARC crop genetic improvement programs by region.

Source: Evenson and Rosegrant, 2003.

	NARSs		IARCs	
	Estimated benefits		Estimated	Lower range
	IRR	B/C	IRR	B/C
Latin America	31	56	39	34
Asia	33	115	115	104
West Asia-North Africa	22	54	165	147
Sub-Saharan Africa	9	4	68	57

Note: The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model developed by IFPRI is a partial equilibrium model covering 17 commodities and 35 country/regions.

Table 8.9 Summary of IRR estimates. Source: Evenson, 2001

	Number of IRRs reported	Distribution						Approx. median IRR
		0-20	21-40	41-60	61-80	81-100	100+	
	(count)			*(percentage)*				
Extension								
Farm observation:	16	56	0	6	6	5	6	18
Aggregate observations	29	24	14	7	0	27	27	80
Combined research and extension	36	14	42	28	03	8	16	37
By region:								
OECD	19	11	31	16	0	11	16	50
Asia	21	24	19	19	14	.09	14	47
Latin America	23	13	26	34	8	.08	.09	46
Africa	10	40	30	20	10	0	0	27
All extension	81	26	23	16	3	.19	13	41
Applied research								
Project evaluation	121	25	31	14	18	6	7	40
Statistical	254	14	20	23	12	10	20	50
Aggregate programs	126	16	27	29	10	9	9	45
Commodity programs:								
Wheat	30	30	13	17	10	13	17	51
Rice	48	8	23	19	27	8	14	60
Maize	25	12	28	12	16	8	24	56
Other cereals	27	26	15	30	11	7	11	47
Fruits and vegetables	34	18	18	09	15	9	32	67
All crops	207	19	19	14	16	10	21	58
Forest products	13	23	31	68	16	0	23	37
Livestock	32	21	31	25	9	3	9	36
By region:								
OECD	146	15	35	21	10	07	11	40
Asia	120	08	18	21	15	11	26	67
Latin America	80	15	29	29	15	7	6	47
Africa	44	27	27	18	11	11	5	37
All applied research	375	18	23	20	14	8	16	49
Pre-invention science	12	0	17	33	17	17	17	60
Private sector R&D	11	18	9	45	9	18	0	50
Ex-ante research	*87*	*32*	*34*	*21*	*6*	*1*	*6*	*42*

Table 8.10 Ranges of rates of return. Source: Alston et al., 2000a

Sample	Number of observations	Rate of return				
		Mean	Mode	Median	Minimum	Maximum
	(*count*)	(*percentage*)				
Full sample[a]						
Research only	1,144	99.6	46.0	48.0	-7.4	5,645
Extension only	80	84.6	47.0	62.9	0	636
Research and extension	628	47.6	28.0	37.0	-100.0	430
All observations	1,852	81.3	40.0	44.3	-100.0	5,645
Regression sample[b]						
Research only	598	79.6	26.0	49.0	-7.4	910
Extension only	18	80.1	91.0	58.4	1.3	350
Research and extension	512	46.6	28.0	36.0	-100.0	430
All observations	1,128	64.6	28.0	42.0	-100.0	910

[a] The original full sample included 292 publications reporting 1,886 observations. Of these, 9 publications were dropped because rather than specific rates of return they reported results such as >100% or <0. As a result of these exclusion, 32 observations were lost. Of the remaining 1,854, two observations were dropped as extreme (and influential) outliers. These two estimates were 724,323% and 455,290% per year.
[b] Excludes outliers and observations that could not be used in the regression owing to incomplete information on explanatory variables.

Table 8.11 Rates of return by commodity orientation. Source: Alston et al., 2000a.

Commodity orientation	Number of observations	Rate of return				
		Mean	Mode	Median	Minimum	Maximum
	(*count*)	(*percentage*)				
Multicommodity[a]	436	80.3 (110.7)	58.0	47.1	-1.0	1,219.0
All agriculture	342	75.7 (110.9)	58.0	44.0	-1.0	1,219.0
Crops and livestock	80	106.3 (115.5)	45.0	59.0	17.0	562.0
Unspecified[b]	14	42.1 (19.8)	16.4	35.9	16.4	69.2
Field crops[c]	916	74.3 (139.4)	40.0	43.6	-100.0	1,720.0
Maize	170	134.5 (271.2)	29.0	47.3	-100.0	1,720.0
Wheat	155	50.4 (39.4)	23.0	40.0	-47.5	290.0
Rice	81	75.0 (75.8)	37.0	51.3	11.4	466.0
Livestock[d]	233	120.7 (481.1)	14.0	53.0	2.5	5,645.0
Tree crops[e]	108	87.6 (216.4)	20.0	33.3	1.4	1,736.0
Resources[f]	78	37.6 (65.0)	7.0	16.5	0.0	457.0
Forestry	60	42.1 (73.0)	7.0	13.6	0.0	457.0
All studies	1,772	81.2 (216.1)	46.0	44.0	-100.0	5,645.0

Notes: See Table 8.10. Standard deviations are given in parentheses. Sample excludes two extreme outliers and includes only returns to research only and combined research and extension, so that the maximum sample size is 1,772. In some instances further observations were lost owing to incomplete information on the specific characteristics of interests.

[a] Includes research identified as all agriculture or crops and livestock, as well as unspecified.

[b] Includes estimates that did not explicitly identify the commodity focus of the research

[c] Includes all crops, barley, beans, cassava, sugar cane, groundnuts, maize, millet, other crops, pigeon pea or chickpea, potato, rice sesame, sorghum and wheat.

[d] Includes beef, swine, poultry, sheep or goats, all livestock, dairy, other livestock, pasture, dairy and beef.

[e] Includes other tree and fruit and nuts.

[f] Includes fishery and forestry.

Table 8.12 Rates of return by geographical region or research performer. Source: Alston et al., 2000a.

Geographical region	Number of estimates	Rate of return				
		Mean	Mode	Median	Minimum	Maximum
	(*count*)	(*percentage*)				
Higher-income countries	990	98.2 (278.1)	19.0	46.0	-14.9	5,645
North America[a]	740	102.4 (306.9)	22.0	46.5	-14.9	5,645
Europe	85	93.9 (152.0)	19.0	62.2	0.0	1,219
Australasia[b]	154	83.7 (177.9)	20.0	28.7	-1.3	1,736
Other developed countries[c]	11	55.6 (36.1)	22.2	37.4	22.2	125
Developing countries	683	60.1 (84.1)	46.0	43.0	-100.0	1,490
Africa	188	49.6 (113.0)	10.9	34.3	-100.0	1,490
Asia and Pacific	222	78.1 (93.2)	49.0	49.5	6.0	1,000
Latin America and Caribbean	262	53.2 (39.3)	46.0	42.9	3.0	325
West Asia and North. Africa	11	44.2 (19.6)	28.0	36.0	28.0	80
Multinational	74	58.8 (98.3)	32.0	34.0	-47.5	677
International agricultural research centers	62	77.8 (188.6)	26.0	40.0	9.9	1,490

Notes: Standard deviations are given in parentheses, Sample excludes two extreme outliers and includes only returns to research only and combined research and extension, so that the maximum sample size is 1,772. In some instances further observations were lost owing to incomplete information on the specific characteristics of interest.
[a] Unites States and Canada;
[b] Australia and New Zealand;
[c] Japan and Israel.

Table 8.13 Summary of results of Economic Assessment of African R&D Investments. Sources: Oehmke et al., 1997); Anandajayasekeram et al., 2007.

Author	Type of analysis	Number of observations	Range of RORs	Range of B/C ratio	Geographical coverage
		(count)	*(percentage)*		
Oehmke et al. (1997)	Ex-post	27	< 0 to 135	—	Sub-Saharan Africa-
	Ex-ante	19	< 0 to 271	1.35 :1 to 149 :1	
	Combined	46	< 0 to 271	1.35 :1 to 149 :1	
Anandajayasekeram et al. (2007)	Econometric methods	25	2 – 113	—	East and Southern Africa
	Non econometric methods	61	< 0 to 109	1.35:1 to 149	
	Combined	86	< 0 to 113	1.35:1 to 149	

Table 8.14 Relative size of environmental impacts of high-external input farming systems in absence of monetized or otherwise quantified assessments. Source: Developed by authors.

		Individual farmer and/or household	Local community	Downstream community	Global society	Data availability for economic quantification*
Agriculture	Biodiversity loss, off and on-farm species and plant genetic resources	--	--	-	-----	Some
	Erosion and soil quality	----	-	----	-----	Many
	Run-off of agro-chemicals (eutrophization)	0	-	-----	---	Many
	Pesticides and impact on non-target species	-	---	----	---	Many
	Water table loss	-	--	-----	-	Few
	Fossil Fuel Use: Non-renewable and climate change impact	-- (financial cost)	0	0	-----	Some
	Genetic improvement	++++++	0	0	++	Many
	Carbon sequestration	0	0	0	+++++	Some
	Land saving	+++++	++	0	++++	Many
Livestock	Biodiversity loss, off- and on-farm species and animal genetic resources	--	--	-	-----	Few
	Water contamination (surface and underground) and eutrophization	-	--	-----	-	Some
	Fossil Fuel Use	--	0	0	---	Some
	Land use and deforestation for animal nutrition	0	0	-	-----	Many
	GHG emissions	0	0	0	-----	Some
	Genetic improvement	++++++	0	0	++	Some
Aquaculture	Fisheries decline (due to fishmeal production and capture of wild gravid females and/or post larvae seeds)	-----	-----	0	--	Few
	Destruction of coast forest (e.g. mangrove for shrimp production)	-----	-----	-----	-----	Some
	Erosion and release of CO_2 into atmosphere	--	--	--	-----	Few
	Fossil Fuel Use	--	0	0	---	Few
	Soil and water salinization	----	-----	-----	-	Few
	Run-off of agro-chemicals	0	-	-----	---	Few
	Biodiversity loss (due to diseases, hybridization and competition with wild-fish)	-	-	--	-----	Few

Notes: + = positive impact. - = negative impact. Degree of impact: + is minimal; ++ moderate; +++ high; ++++ very high, and +++++ very high likelihood of some irreversibility.

[a] Economic valuation refers both to monetary and other methods of valuation tools.

[b] Agriculture impacts include the livestock and aquaculture impact derived from the crops required for the animal and fish nutrition industry (e.g. 33% of world feedcrop land is dedicated to animal nutrition, thus, it is a livestock impact added to agriculture).

Table 8.15 Positive contributions of AKST for human health by sector

Sector	AKST product	Consequences for human health	Data availability for economic quantification
Crops	Micronutrient trait in crop varieties	Prevent human diseases	Ex-ante assessments for Biofortification
Livestock	Animal Protein	Balanced diet	Unknown
Aquaculture	Animal Protein and micronutirents	Balanced diet	Unknown
Forestry	Non-timber products and food from natural resources	Prevent food insecurity	Unknown

Table 8.16 Negative effects of AKST for human health by sector

Sector	Type of effect	Consequences	Data availability for economic quantification
Crops		Acute and chronic diseases	Case studies including economic evaluations and occasional country statistics
	Water pollution with pesticides and nitrogen fertilizer	Intoxication/death from drinking water	Statistics and case studies mainly in developed countries
	Air pollution (e.g., transport, fertilizers production, deforestation)	Respiratory and allergic diseases	Unknown
Livestock	Increase of cheap meat production and consumption	Obesity (cancer, diabetes, coronary diseases)	Studies mainly for US
	Antibiotics use	Increasing resistance to antibiotics	Few studies
	Water pollution with animal wastes	Intoxication/death from drinking water	Unknown
	Air pollution (transport, GHG emissions, deforestation)	Respiratory and allergic diseases	Unknown
	Increasing animal trade	Increasing number of zoonosis	Recent studies
Aquaculture	Antibiotics use	Increasing resistance to antibiotics	Few studies
	Air pollution (transport)	Respiratory and allergic diseases	Unknown
	Residues in aquaculture feed (mercury, dioxins, polychlorinated bromides	Intoxication, neurotoxicity	Few studies

Table 8.17 Economic impact studies: Private sector R&D spill-in and pre-invention science spill-in. Source: Evenson, 2001.

Study	Country/ region	Period of study	IRR
Private sector R&D spill-in:			
Rosegrant and Evenson (1993)	India	1956-87	Domestic 50+ Foreign 50+
Huffman and Evenson (1993)	US	1950-85	Crops 41
Ulrich et al. (1985)	Canada		Malting barley 35
Gopinath and Roe (1996)	US	1991	Food processing 7.2 Farm machinery 1.6 Total social 46.2
Evenson (1991)	US	1950-85	Crop 45-71 Livestock 81-89
Evenson and Avila (1996)	Brazil	1970-75-80-85	NC
Pre-invention science spill-in:			
Evenson (1979)	US	1927-50 1946-71	110 45
Huffman and Evenson (1993)	USA	1950-85	Crops 57 Livestock 83 Aggregate 64
Evenson et al. (1999)	India	1954-87	Domestic Foreign
Evenson and Flores (1978)	Int. (IRRI)	1966-75	74-100
Evenson (1991)	US	1950-85	Crops 40-59 Livestock 54-83
Azam et al. (1991)	Pakistan	1966-68	39

Figure 8.8 The conditioning of agricultural growth and distributional effects. Source: Von Braun, 2003

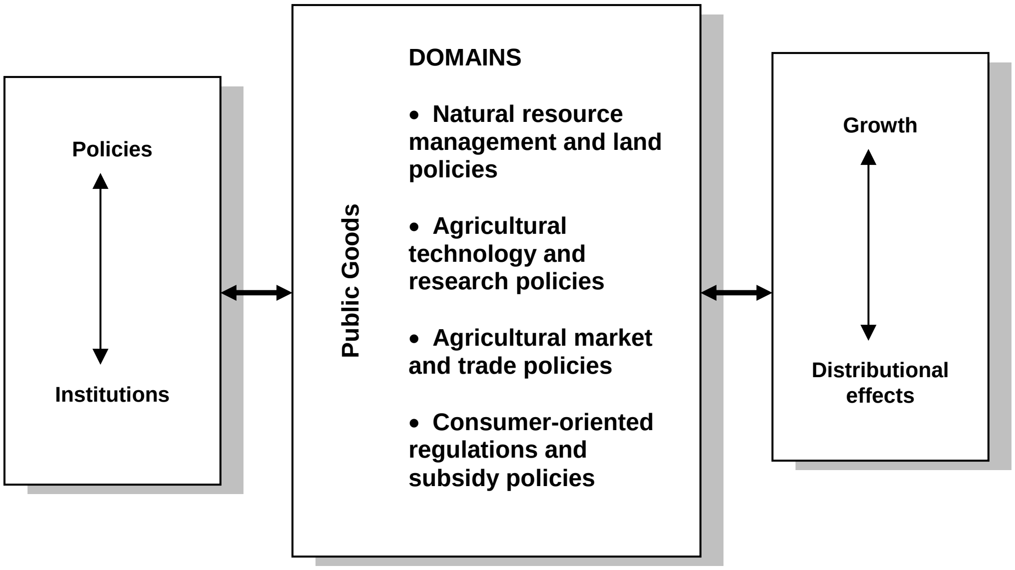


Table 8.18 Ranking of public investment effects in selected Asian and African countries. Sources: Fan et al., 2005, 2004a, b; 2000; Fan and Zhang, 2004; Mogues et al., 2006.

	China	India	Thailand	Vietnam	Uganda	Tanzania	Ethiopia
	Ranking of returns in agricultural production						
Agricultural R&D	1	1	1	1	1	1 (52.46)	3
Irrigation	5	4	5	6			
Education	2	3	3	3	3	3 (9.00)	2
Roads	3	2	4	4	2	2 (9.13)	1
Telecommunications	4			2			
Electricity	6	8	2	5			
Health		7			4		
Soil and water conservation		6					
Anti-poverty programs		5					
	Ranking of returns in poverty reduction						
Agricultural R&D	2	2	2	1	1	3*	
Irrigation	7	7	5	6			
Education	1	3	4	3	3	2	
Roads	3	1	3	4	2	4	
Telecommunications	4			2		1	
Electricity	5	8	1	5			
Health		6			4		
Soil and water conservation		5					
Anti-poverty programs	6	4					

BOX 8.2 On the theoretical framework to analyze governance.

There are different streams of theoretical literature informing the discussion on governance. One such framework is that of New Institutional Economics (NIE), an extended framework of neoclassical economics. It takes into account demand factors such as the role of relative prices since such prices play an important role in deciding what is an appropriate institution in a given context. However NIE admits the possibility that the evolution of appropriate institutional innovation need not be an automatic process. There can be social, political, and even institutional reasons that distort' or blunt the evolution of appropriate institutions. There has been significant development in institutional analysis during the last two decades highlighting the possibilities of persistence of institutional inefficiency due to reasons of path dependence, political economy and informational problems. An alternative framework is that of` the national innovation system (NIS) (Freeman, 1987; Lundvall, 1992). It treats R&D as an innovation system in which both the producers and users are seen as parts of the same system and attempts to identify certain patterns in system relationships, governance, capacity-building or learning, evolving roles, and wider institutional contexts (Hall and Yoganand, 2002). However from the point of view of NIE, NIS approach lacks a coherent theoretical framework, and thus is unable to develop consistent stories or explanations of different institutional changes taking place in different socio-economic contexts. Meanwhile, the criticism of the innovation system proponents on the NIE-based approach would be that the latter is inadequate to handle power structures and learning. However the issues of incorrect learning and information problems have become part of the agenda of NIE increasingly in the nineties (North, 1991) and the New Political Economy takes into account the role of power struggles in facilitating or blocking beneficial institutional changes.

Table 8.19 Guiding questions for institutional assessment on governance

Issue/Actor	Guiding Question
Governance	1. What are the appropriate intervention strategies in different sectors given the overall social objectives?
	2. What is the appropriate intervention given the objectives in the agricultural sector?
	3. What is the problem of market failure to be addressed?
	4. What is the institutional mechanism required given the problem of market failure?
	5. How to ensure that governance decisions are accountable and transparent?
Institutions	6. Is the institutional arrangement capable of meeting the objective?
	7. Is the institutional arrangement capable to internalize the requirements or demands of its potential clients?
	8. Is the institutional arrangement leading to efficient decisions given its alternatives?
	9. Does the arrangement have flexibility to evolve in tune with the changing socio-economic realities?
Organizations	10. What kind of feedback is likely to be generated by the organizations operating within this institutional framework?
Individuals	11. Are the incentives (monetary as well as other non-monetary rewards) of the individual actors aligned with the stated objectives of the organizations?

Box 8.3 Experience of new funding options in African countries

Many African countries have implemented new governance enhancing strategies such as; separation of policy making, funding and service provision, decentralization of public administration, deconcentration of service provision, and empowerment of communities and farmers organizations. Experience from Tanzania and Benin (Heemskerk and Wennink, 2005) have shown that local R&D funding schemes have contributed significantly to financial diversification for agricultural innovation. However, real and substantial empowerment of farmers' organizations in controlling financial research for adaptive research and pre-extension is still low. Although downward accountability has improved, real client control of funds has stagnated and Farmers' representation in management teams of competitive grant schemes remains weak due to traditional top down attitudes of researchers and research managers.

Decentralization and deconcentration of local innovation development funds have been more successful in technology generation, and in fostering the competitive element, which has enhanced the quality of research and the sense of ownership. Nonetheless, other concerns such as; developing more viable mechanisms for client representation, priority focus and pro-poor focus of available funds, level of co-sharing and cost sharing are all yet to be resolved. In addition, some of the competitive grants and commodity based innovation development funds are insufficiently integrated into the national financing system.

In terms of effectiveness and efficiency, there is evidence that more adaptive technologies are flowing to farmers under competitive funding, but there is no effective mechanism to systematize the information on the innovation adoption process. There has also been improvement in priority setting, planning and implementation, but not as much in monitoring and financing. Competitive grants tend to spread resources too thinly. Experience in Tanzania showed that effectiveness of competitive grants could be improved by focusing on a single theme using the value chain approach. Another disadvantage in the African context is that competition may be limited due to insufficient numbers of competent researchers. In addition, competitive funds in African have been dependent on donors, whose pledges by donors have sometimes not been forthcoming. Co-financing from local sources has also been unpredictable. Competitive funds are also expensive to operate due to high transaction cost especially for monitoring and evaluation (Lema and Kapange, 2005ab).

Table 8.20 Summary of impacts of productivity increasing technology – economic returns, externalities and spillovers. Sources: Evenson 2001, Alston et al (2000a) and the judgments of the authors.

	Median of ROR for Productivity Increases		Environmental externalities	Health externalities	Impact on poor
	Evenson (2001)	Alston et al. (2001a)			
All crops	57	44			0
Wheat	51	40	- - Irrigation with poor drainage + high yields reduce need to clear forest	0/+	+/-
Rice	60	51	- - over irrigation & high pesticide use + high yields reduce need to clear forest	- pesticides	+/-
Maize	56	47	- - over irrigation & high pesticides + high yields reduce need to clear forest	- pesticides	+/-
Other cereals	57	na			+/-
Fruits and vegetables	67	na	-- high pesticide use	-- high pesticides affect laborers & consumers + improves nutrients in diet	+ home gardens/- commercial
Livestock	36	53	-- for intensive livestock production which can lead to nitrogen and phosphorus pollution of water	- zoonotic diseases - food poisoning + increases protein & minerals in diet	+ if subsistence or milk coops - if intensive or contract production???
Forestry	na	14			+ if agroforestry
Forest products	37	na			?
Tree crops	na	33	- plantations that replace uncultivated land can reduce biodiversity + plantations that replace crops could be a carbon sink		- if plantations
Resource management	na	17	++ for more effective management which substitutes labor for chemicals	+ if reduce use of pesticides	+ if saving resources of poor or tech is labor intensive
Developing countries	37-67	43			
CGIAR	39-165	40			++
Private	50	34	-- intensive livestock and pesticide use, but management & biotech can reduce chemical pesticides	- if increases pesticide use + if it reduces pesticide use	- or 0

Notes: - small negative impact, -- large negative impact, + small positive impact, and ++ large positive impact, na means not available.