Agricultural research and extension funding levels required to meet the Anti-Hunger Programme objectives

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Table of contents

List of tables

List of figures

Executive Summary

The strengthening of agricultural research and extension is one of the five priority themes formulated by FAO's Anti-Hunger Programme in order to achieve this goal. The other four priority themes are: (1) Improve agricultural productivity and enhance livelihoods and food security in poor rural communities; (2) Develop and conserve natural resources; (3) Expand rural infrastructure and broaden market access; and (4) Ensure access to food for the most needy through safety nets and other direct assistance. The paper provides an overview of levels and trends in agricultural research and extension investments; summarizes economic impact evidence of past investments in agricultural research and extension; provides an estimate of the additional investment needed across regions and income levels; discusses how the international community could assist developing countries in achieving this increase in agricultural research and extension investment; looks at ways of organizing and financing agricultural research and extension at the national level; discusses the priority areas for agricultural research and extension; and finally draws conclusions. Annual average growth of public agricultural research expenditures has slowed down considerably in both developed and developing countries. Many developed countries (and even some developing countries) are in the process of shifting the funding of extension services to the users and away from public resources. The six factors identified as shaping the overall profitability of Research and Development (R&D) investments include (1) technological knowledge; (2) economies of scale; (3) industry structure; (4) R&D efficiency and effectiveness; (5) adoption rate; and (6) risk and uncertainty. An investment target of 2% of agricultural GDP in agricultural research and extension combined would be a reasonable and defendable target, which should bring the actual growth of the agricultural sector closer to its potential growth. The international donor community can assist and support national governments to raise their investments in agricultural research and extension. An international *matching budget support facility* for national agricultural research and extension would be more equitable. For every x dollars that a government spends on agricultural research and extension this international facility would provide one dollar extra. The maximum amount that the budget support system would cost annually is US$ 1.8 billion. Much of the reform debate in agricultural innovation focuses on the privatization of agricultural research and extension services. In most developing countries, agricultural research and extension is predominantly financed by general tax revenues and implemented by government agencies. The agricultural research and extension reforms are characterised by (1) a redefinition of the role of government in the provision of research and extension services (2) decentralization of agricultural research and extension services, (3) improved service orientation (4) outsourcing of implementation of agricultural and extension services to private non- profit agencies, and (5) application of rule that those who benefit should pay. The international development community has identified two important priority areas for public agricultural research and extension, namely: (1) poor farmers in marginal areas (this is in line with the strong international emphasis on poverty reduction); and (2) sustainable management of natural resources. Many countries see an important role for public agricultural research and extension to help farmers to diversify into high-value-adding activities that generate income and foreign exchange. There is a widely shared opinion that there is considerable underinvestment in public agricultural research and extension. The ongoing reforms in agricultural research and extension, which have been strongly influenced, are attempts to improve the efficiency and effectiveness of these services. This paper sets a minimum expenditure target for low-income and lower middle-income countries of 2% of agricultural GDP for public agricultural research and extension combined. Investments in agricultural innovation can only prosper in an enabling environment. Political and economic stability are important preconditions, while investments in education, health, rural infrastructure, and markets may substantially enhance innovation opportunities and hence increase the attractiveness of more investment in agricultural innovation.

1. Introduction

FAO's Anti-Hunger Programme sets out key actions that must be taken internationally and by countries themselves to achieve the World Food Summit (WFS) target of halving the number of chronically undernourished by 2015. The strengthening of agricultural research and extension is one of the five priority themes formulated by the Programme in order to achieve this goal (FAO 2002). The other four priority themes are: (1) Improve agricultural productivity and enhance livelihoods and food security in poor rural communities; (2) Develop and conserve natural resources; (3) Expand rural infrastructure and broaden market access; and (4) Ensure access to food for the most needy through safety nets and other direct assistance (FAO 2002). These five priority themes should be seen as closely interrelated and reinforcing each other. Hence the strengthening of agricultural research and extension is to be screened nor only for its wealth creation but also for its contribution to food security, poverty reduction, and environmental sustainability. Within this context, this paper addresses the question of how much more should be invested in agricultural research in order to achieve WFS targets.

It should be clear from the outset that this is a difficult question to answer and that a paper like this can only provide a very broad brush picture of what needs to be done. Local policymakers and stakeholders have to assess carefully how much more investment in agricultural research and extension is really warranted in their specific situation, because innovation opportunities very much differ from situation to situation and from time to time. Nevertheless, we have tried to formulate minimum targets for public agricultural research and extension investment based on investment experiences in the past and by comparing countries at different stages of economic development. We hope that our arguments will convince national and international policymakers to substantially increase public agricultural research and extension investments.

The structure of this paper is as follows: section 2 provides an overview of levels and trends in agricultural research and extension investments and section 3 summarizes economic impact evidence of past investments in agricultural research and extension. By adopting a minimum investment target, section 4 provides an estimate of the additional investment needed across regions and income levels. Section 5 discusses how the international community could assist developing countries in achieving this increase in agricultural research and extension investment. New ways of organizing and financing agricultural research and extension at the national level are discussed in section 6, while section 7 discusses the priority areas for agricultural research and extension. Conclusions are drawn in section 8.

2. Investment levels and trends in agricultural research and extension

For thousands of years, agricultural innovation has been a slow process based on knowledge accumulation by farmers – knowledge that was passed on from generation to generation. Learning by doing slowly improved agricultural techniques, while the genetic base of agricultural plants and animals slowly improved by farmer selection. In the 19th century, however, the process of agricultural innovation accelerated substantially as for the first time science was being applied to agricultural production. It eventually led to the establishment of formal agricultural research agencies throughout the world, whose capacity has expanded quite dramatically throughout the 20th century. Initially, agricultural extension was usually an integral part of the activities to be performed by public agricultural research agencies. A division of labour emerged later on and extension became a separately organized activity in most countries. A notable exception, however, are the state agricultural experiment stations in the USA that until today combine research and extension activities.

The most recent global estimate of agricultural research expenditures stands at \$21.7 billion (1993 international dollars) in 1995, nearly \$10 billion more than 20 years earlier. The larger part of these expenditures (\$11.5 billion) takes place in developing countries (table 1). The expenditure data used to construct these global totals have been collected in current local currency, deflated to base year 1993 using local GDP deflator series, and then converted to international dollars by using the 1993 purchasing power parity (PPP) index. A PPP index is an artificial exchange rate based on buying the same representative basket of goods and services in each country. It attempts to eliminate the difference in purchasing power that a US dollar may have in different countries. This method is considered superior to using market exchange rates when it comes to cross-country comparisons. The same data expressed in 1993 US dollars (using market exchange rates rather than PPP indices) gives a substantially different picture as can be seen in the last column of table 1. The balance shifts to the developed countries. In this calculation they are good for more than two-thirds of global spending on agricultural research. In the remainder of this paper we will use US dollars rather than PPP-based international dollars for practical reasons such as the fact that actual transactions (e.g. donor support) are done in US dollars rather than in artificial international dollars.

Table 1: *Global public agricultural research expenditures, 1976-95*

	1976	1985	1995	1996
	(million 1993 international dollars)			*(million 1993 US dollars)*
Developing countries (119)	4,738	7,676	11,469	4,892
Sub-Saharan Africa (44)	993	1,181	1,270	555
China	709	1,396	2,063	598
Asia & Pacific, excl. China (23)	1,321	2,453	4,619	1,645
Latin America & Caribbean (35)	1,087	1,583	1,917	1,297
Middle East & North Africa (15)	582	981	1,521	797
Developed countries (34)	7,099	8,748	10,215	12,068
Total (153)	*11,837*	*16,424*	*21,692*	*16,960*

Source: Pardey and Beintema (2001)
Note: These estimates exclude Eastern Europe and the former Soviet Union countries due to incomplete data.

As shown in table 2, annual average growth of public agricultural research expenditures has slowed down considerable in both developed and developing countries. Growth has been particularly sluggish in sub-Saharan Africa (1986-96) and Latin America and the Caribbean (1981-1991). In both regions, agricultural research expenditures have contracted in a considerable number of countries for longer periods of time. Agricultural research expenditure in Asia in contrast continued to grow relatively strong.

Table 2: *Annual growth rates of public agricultural research expenditures, 1976-96*

	1976-81	1981-86	1986-91	1991-96
		(percentage)		
Developing countries (119)	7.0	3.9	3.9	3.6
Sub-Saharan Africa (44)	1.7	1.4	0.5	-0.2
China	7.8	8.9	2.8	5.5
Asia & Pacific, excl. China (23)	8.2	5.1	7.5	4.4
Latin America & Caribbean (35)	9.5	0.5	0.4	2.9
Middle East & North Africa (15)	7.4	4.0	4.2	3.5
Developed countries (34)	2.5	1.9	2.2	0.2
Total (153)	*4.5*	*2.9*	*3.0*	*2.0*

Source: Pardey and Beintema (2001)

Despite the higher growth in agricultural research expenditures in developing countries, the most common research intensity ratio (i.e., expenditures as a percentage of agricultural GDP) has increased only very modestly for developing countries (from 0.44% in 1976 to 0.62% in 1995), but increased steeply for the developed countries (from 1.53% in 1976 to 2.64% in 1995) (see table 3). This latter phenomenon is caused by a very slow growth or even stagnation of agricultural GDP in developed countries during the past 25 years. Despite its initially relatively high score compared to other developing regions, the contraction in research intensity noted for sub-Saharan Africa is a major concern.

Table 3: *Selected public research intensity ratios, weighted averages, 1976-95*

	Expenditures as a share of AgGDP			Expenditures per agricultural labourer		
	1976	1985	1995	1976	1985	1995
	(percentage)			*(1993 int. dollars)*		
Developing countries	0.44	0.53	0.62	4.6	6.5	8.5
Sub-Saharan Africa	0.91	0.95	0.85	11.3	10.6	9.4
China	0.41	0.42	0.43	1.8	3.1	4.1
Other Asia	0.31	0.44	0.63	2.8	6.1	10.2
Latin America & Caribbean	0.55	0.72	0.98	26.0	36.0	45.9
Developed countries	1.53	2.13	2.64	238.5	371.0	594.0
Total	*0.83*	*0.95*	*1.04*	*12.0*	*15.3*	*17.7*

Source: Pardey and Beintema (2001)

In addition to the investments in public agricultural research, there are also very substantial investments in research by private companies that serve the agricultural sector such as agro-chemical industries, veterinary pharmaceutical industries, agricultural machinery industries, seed industries, and animal feed industries. Most of these industries are dominated by multinationals who have concentrated the bulk of their research activities in developed countries (table 4). Their sales, however, are global and so the economic impact of their research goes far beyond the country where the research is being conducted.

Table 4: *Estimated global public and private agricultural R&D investments, circa 1995*

	Expenditures			Shares		
	Public	Private	Total	Public	Private	Total
	(million 1993 int. dollars)			*(percentage)*		
Developing countries	11,469	672	12,141	94.5	5.5	100
Developed countries	10,215	10,829	21,044	48.5	51.5	100
Total	*21,692*	*11,511*	*33,204*	*65.3*	*34.7*	*100*

Source: Pardey and Beintema (2001).

Expenditure data on agricultural extension have been far less well recorded internationally than expenditure data on agricultural research. Pioneering work by Boyce and Evenson (1975) and Judd *et al* (1983) on global extension expenditures has only once been updated by an FAO study in the late 1980s (Swanson, Farner, and Bahal 1990). Table 5 provides a snapshot estimate of the total number of extension agents worldwide in 1988 and an estimate of total extension expenditures in current US dollars based on this latter study. We inflated these expenditures to 1993 US dollars (last column table 3) in order to make them more comparable with the research expenditure data reported in table 1.[1] In 1988, the total number of agricultural extension agents worldwide was in the order of 600,000 and spending an approximately US$ 5 billion (or US$ 5.7 billion in 1993 US dollars). This is considerably less than the US$ 17 billion (1993 US dollars) spent on agricultural research in 1996.

Table 5: *Global estimates of agricultural extension staff and expenditures, 1988*

	Extension staff	Extension expenditures	Extension expenditures
	(#)	*(million US dollars)*	*(million 1993 US dollars)*
Developing countries	497,168	2,500	2,932
Africa	58,958	400	469
China	193,300	452	530
Asia & Pacific, excl. China	184,797	1166	1,368
Latin America & Caribbean	14,498	195	229
Near East	32,965	287	337
Developed countries	58,351	2,354	2,761
USA	15,274	1,025	1,202
Japan	12,400	288	337
Other developed countries (a)	30,677	1,041	1,221
Total	555,519	4,854	5,693

Sources: Swanson, Farner, and Bahal (1990); FAO (1991); Alston and Pardey (1996).
Note: Extension expenditure data were constructed by Swanson *et al* by multiplying the number of extension staff with a regional average of "expenditures per extension staff." Hence the reported expenditure figures are very crude, indirect estimates. We corrected the data by reporting China separately, which caused a substantial drop in expenditures because the Chinese expenditure per extension staff figure (FAO 1991) is substantially lower than the Asian regional average (US$ 2,337 rather than US$ 6,312). Because of the large number of extension staff in China, the difference is some US$ 768 million. In addition, we moved Australia, Japan and New Zealand from Asia & Pacific to the developed country category. The original Swanson *et al* figures have a very incomplete coverage of the developed countries. For example, the USA extension expenditure figure reported by Swanson *et al* covers only federal expenditures (US$ 364 million). The USA extension expenditure figure reported in the table has been derived from Alston and Pardey (1996) and has a substantially better coverage, including federal, state and county contributions.
(a) Constructed by multiplying the total number of agricultural labourers with the average farmers-to-agent ratio (431) reported by Swanson *et al* for four European countries. The expenditure figure was estimated by assuming an expenditure-per-extension-agent figure of US$ 20,000 for Greece, Spain and Portugal, and US$ 40,000 for all other developed countries. For comparison, the reported expenditure-per-extension-agent was some US$ 67,100 in the USA and US$ 23,200 in Japan.

[1] The regional groupings in tables 1 and 5 are not exactly comparable. Most importantly, North Africa is reported under Africa in table 5 and under Middle East & North Africa in table 1.

Swanson, Farner, and Bahal (1990) report various extension intensity ratios, averaged by region (see table 6). Rather than reporting weighted averages (as in table 3), they report mean averages, which means that each country observation is given the same weight.[2] As they discuss in their text, the reported mean averages tend to give a rather inflated picture compared to weighted averages. For example, while the bigger countries report extension expenditure intensities in the order of 0.4% of agricultural GDP, several smaller developing countries report extension expenditure intensities in the order of 2-6% of agricultural GDP. Swanson, Farner, and Bahal (1990) estimate that the global "weighted average" extension expenditure intensity ratio to be in the order of 0.5% of agricultural GDP.

Table 6: *Selected public agricultural extension intensity ratios, mean averages*

	Expenditures as a share of AgGDP			Farmers per extension agent (1988)	Hectares of arable land per extension agent (1988)
	1980	1985	1988		
		(percentage)			
Africa	1.17	0.98	0.98	1,809	2,245
Asia & Pacific	0.48	0.68	0.56	2,661	1,075
of which China	NA	NA	0.44	2,455	629
Latin America	1.22	0.90	1.40	2,940	3,983
Near East	NA	0.96	1.00	2,499	5,403
USA	1.00	NA	1.15	325	19,441
Japan	0.42	0.37	0.37	407	337
Other developed countries	0.44	0.47	0.48	431	3,719
World-wide average	*0.96*	*0.87*	*0.88*	*NA*	*NA*

Source: Swanson, Farner, and Bahal (1990), FAO (1991), and Alston and Pardey (1996).
Note: The intensity ratios reported here are mean averages, which means that each country observation is given the same weight. Because small countries tend to spend relatively more on extension than big countries, the mean average differs from the weighted average by quite a margin.

When grouping the extension expenditure intensity ratios by income group (low, lower-middle, higher-middle, and high), the mean intensity ratio increases from 0.84% of agricultural GDP in low income countries, to 1.10% in lower-middle income countries, but then drops to 0.68% in higher-middle income countries and to 0.42% in high income

[2] To calculate a weighted average, the national nominator and denominator data of a ratio are added up separately before calculating a regional ratio. A mean average is calculated by taking the average of the national ratios.

countries (Swanson *et al* 1990).[3] This structural pattern of investment in public agricultural extension differs from that noted for public agricultural research expenditures, the intensity of which as a percentage of agricultural GDP steadily increases going from low- to high-income countries as well as through time. In other words, economic progress comes with a higher public research intensity ratio (and they reinforce each other) but not (particular at later stages of development) with a higher public extension intensity ratio. The latter can be explained by the fact that when incomes rise, other channels of knowledge diffusion than direct contact with a public extension agent become more important, such as newspapers, journals, radio, television, internet, and input suppliers. Moreover, the number of farmers to be reached for a given volume of output dramatically declines at later stages of development. On top of all this, since the mid-1980s there has been a move to shift the funding of agricultural extension to the users and away from public resources.

The average number of farmers per extension agent does not differ greatly across the developing regions, but is considerably lower for developed countries (table 3). So while a farmer in a developed country is provided with more public extension services than a farmer in a developing country (and the quality of those services is probably also considerably better), the extension costs per unit output are the same or less.

The number of hectares of arable land that extension agents have to service differs greatly across regions and countries. An extension agent in the United States, for example, services an arable land area that is on average 50 times bigger than that of his colleague in Japan. This may explain in part the higher extension expenditure intensity reported for the United States. The lower extension expenditure intensity reported for the Asia & Pacific region may also be explained by the smaller number of hectares to be serviced per extension

[3] Older extension expenditure data reported by Evenson (1986) for the years 1959, 1970 and 1980 roughly confirms this pattern.

agent. Or to put it the other way round, the more closely farmers live together the more farmers an extension agent can reach effectively.

Due to lack of consistent time series on agricultural extension expenditures, it is impossible to construct an overall picture of extension investment growth rates similar to those of agricultural research in table 2. Roughly speaking, however, public agricultural extension expenditures grew rapidly during the 1960s and 1970s but grew more slowly (and in several instances even contracted) during the 1980s and 1990s. In many developing countries economic and debt crises have taken their toll during the past 20 years and placed a major constraint on government expenditure, including those on agricultural extension. In addition, agricultural extension has gone through severe institutional crises and major reorganizations in many countries.

Starting in the mid-1980s, several developed countries (e.g., the Netherlands, New Zealand, and England & Wales, but notably not the USA) privatized their agricultural extension services in terms of the provision of those services as well as the financing of it. In the Netherlands, for example, all extension personnel was transferred from the Ministry of Agriculture to independent non-profit agencies (and loosing their civil service status in the process), while the funding of these agencies was shifted progressively to the extension clients, i.e. the farmers. Still some public money is channelled through these agencies by the Ministry of Agriculture for specific projects, but the total amount spent by the Ministry of Agriculture on extension dropped from 0.44% of agricultural GDP in 1980 to only 0.14% of agricultural GDP in 1999. It seems that many other developed countries (and even some developing countries) are in the process of adopting similar policies and shifting the funding of extension services to the users and away from public resources. It is not necessary but quite likely that this privatization will result in a reduction of the volume of extension services provided to farmers.

3. Rate-of-return evidence

A standard way of measuring the economic impact of an investment is that of a rate-of-return calculation. There are roughly two groups of rate-of-return estimations, namely (1) a project evaluation approach (also known as the economic surplus approach); and (2) a statistical estimation approach utilizing a production function. The former yields an average internal rate of return (IRR), while the latter yields a marginal IRR.

The common method for measuring the impact of extension is that of statistical estimation, while in the case of research both methods are being applied (Evenson 2001).[4] Table 7 provides an overview of the results of several hundreds economic impact studies on agricultural research and extension across the world.[5] It sketches a very positive overall picture, with a median IRR of 41% for extension and of 49% for research. There is an enormous spread around these medians from very high to low and in a few instances even negative IRRs. Not every dollar invested in research or extension is commanding a high rate of return – there are also a considerable number of failures.

There is undoubtedly a bias in the present compilation of rate-of-return studies towards the success cases. Success projects or programs have a higher chance of being evaluated, while evaluations showing no or negative impact are less likely to be published.[6] While for some this is an argument to disregard the rate-of-return evidence altogether, Evenson (2001) argues that the bias is relatively modest and that the impact evidence is robust enough to consider agricultural research and extension as high payoff investment opportunities.

[4] The project evaluation approach requires an estimation of the "without case" against which the investment is to be compared. For extension this tends to be rather difficult (also without extension knowledge and technology will be transferred, but more slowly), hence the preference for statistical methods.
[5] There are far fewer economic impact studies available on extension than on research.
[6] All rates-of-return presented in table 7 have been derived from formally reviewed and published studies.

Table 7: *Summary of internal rate-of-return (IRR) observations for agricultural extension and research*

	Number of IRRs reported	Percent distribution						Approx. median IRR
		0-20	21-40	41-60	61-70	81-100	>100	
	(#)	*(percentage share)*						(%)
All extension	81	0.26	0.23	0.16	0.03	0.19	0.13	41
By region:								
Africa	10	0.40	0.30	0.20	0.10	0	0	27
Asia	21	0.24	0.19	0.19	0.14	0.09	0.14	47
Latin America	23	0.13	0.26	0.34	0.08	0.08	0.09	46
OECD	19	0.11	0.31	0.16	0.16	0.11	0.16	50
Applied research	375	0.18	0.23	0.20	0.14	0.08	0.16	49
By region:								
Africa	44	0.27	0.27	0.18	0.11	0.11	0.05	37
Asia	120	0.08	0.18	0.21	0.15	0.11	0.26	67
Latin America	80	0.15	0.29	0.29	0.15	0.07	0.06	47
OECD	146	0.15	0.35	0.21	0.10	0.07	0.11	40

Source: Evenson (2001).

A differentiation of the rate-of-return evidence by region suggests that the economic impact of agricultural research and extension has been on average weaker in Africa than in other regions, while the economic impact of research has been particularly strong in Asia.

The very high rates of return reported on agricultural research are for many economists an indication that there has been significant underinvestment in agricultural research (Ruttan 1980; Pinstrup-Anderson 2001). This argument holds for both poor and rich countries. While in the literature the discussion focuses mainly on agricultural research, the reported high rates-of-return on extension would suggest the same for public extension services. It remains puzzling, however, how the reported high rates on extension match with the picture that emerges from the descriptive literature, which suggests that in many developing countries the extension services are underperforming and in deep crisis (Rivera *et al* 2001, Anderson and Feder 2003).

Roseboom (2002a, b and 2003b) further explored the underinvestment argument for agricultural research and estimated (based on a combination of ex post rate-of-return evidence and expenditure data) an underinvestment gap of 140% for developing countries and 40% for developed countries for the period 1981-85. Assuming full information and project selection rationality, the optimal agricultural research investment intensity for the period 1981-85 was estimated retrospectively at 1.0% of agricultural GDP for developing countries (actual 0.4%) and 2.8% for developed countries (actual 2.0%) (figure 1).

Not meeting the assumptions of full information and project selection rationality, may to a large extent explain why underinvestment in agricultural research exists (Roseboom 2003a, b). The ex ante information about the profitability of proposed research projects is generally very weak and many of the variables needed to calculate a rate-of-return can only be predicted with substantial uncertainty. Moreover, project selection in research is influenced by many other factors than expected economic impact. The weaker lobby capabilities of poor farmers may make that in particular they loose out in such situations and that (perhaps against common belief) a stricter adherence to economic selection criteria will be favourable to poor farmers (Roseboom *et al* 2003).

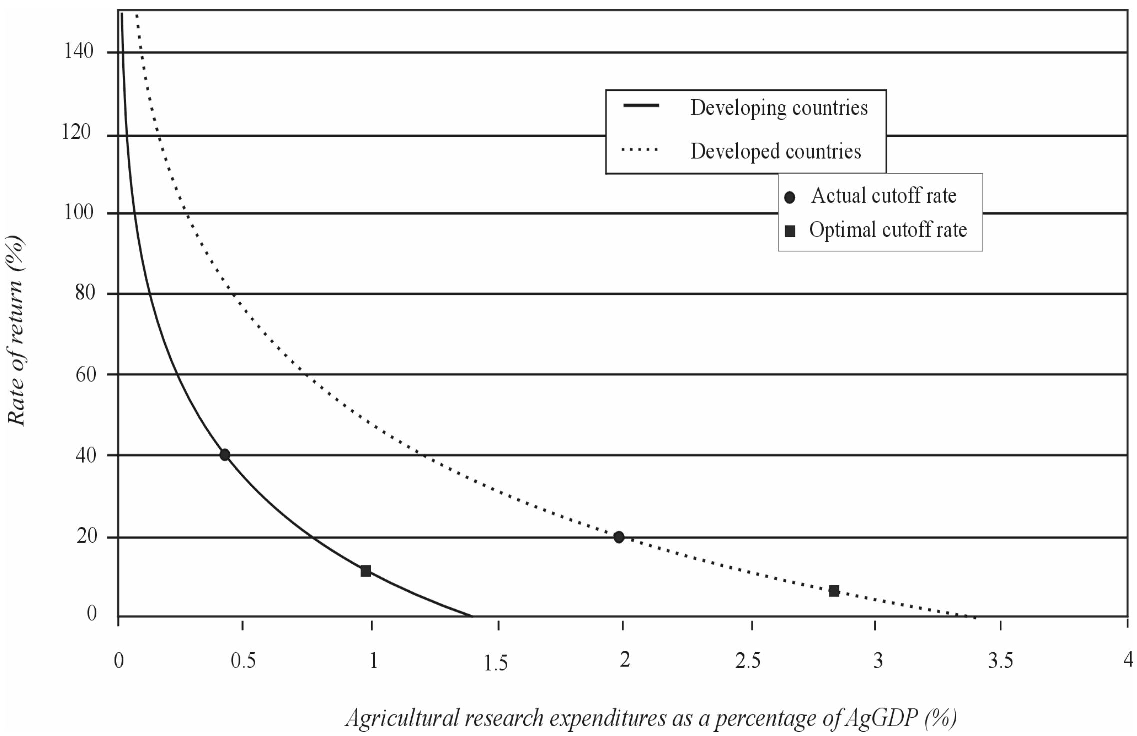

Figure 1: *Agricultural R&D opportunity curves for developed and developing countries – 1981-85*

An important insight is that while the estimated underinvestment gap is considerably bigger for developing countries than for developed countries, the optimal intensity ratios differ considerably. The innovation opportunities for developed countries are considerably better than for developing countries and hence the noted differential in research intensity. Moreover, the R&D opportunity curves are not fixed. Between 1961-65 and 1981-85 the R&D opportunity curves have moved outward, making the optimal R&D intensity a moving target (figure 2).

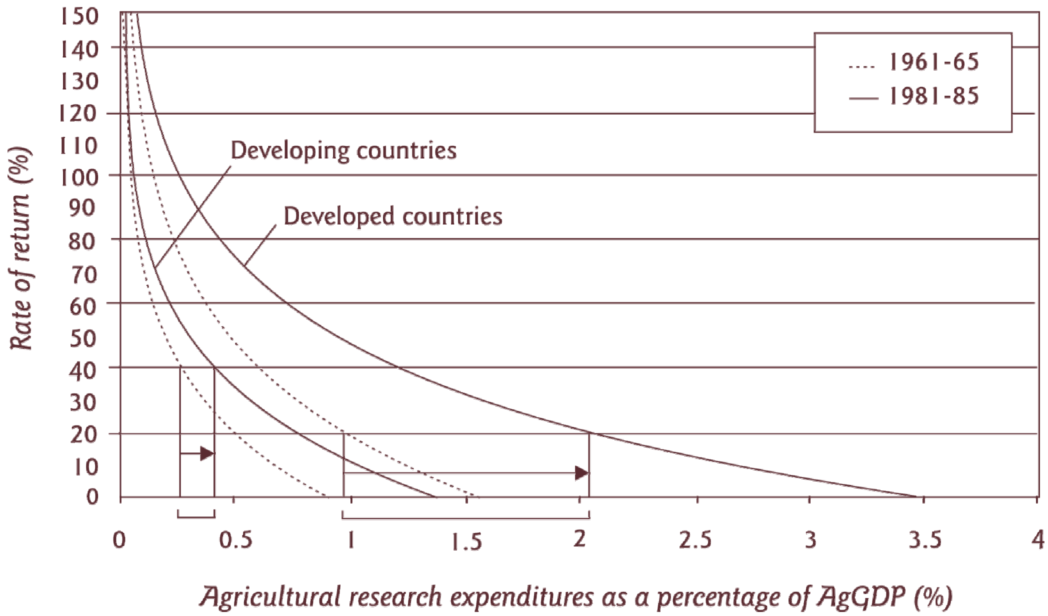

Figure 2: *The shift of the R&D opportunity curve over time*

The following six factors have been identified as shaping the overall profitability of R&D investments and hence the position of the R&D opportunity curve: (1) technological knowledge; (2) economies of scale; (3) industry structure; (4) R&D efficiency and effectiveness; (5) adoption rate; and (6) risk and uncertainty. Each factor could be enhanced by policies as summarized in table 8 and hence help to shift the R&D opportunity curve further out despite the popular idea of exhaustion of innovation opportunities.

Table 8: *Policies that enhance the profitability of R&D opportunities*

Factor	*Policies that could have a positive effect on this factor*
Technological knowledge	Investment in basic science, training of researchers, and improved access to knowledge (e.g., by exploiting the opportunities provided by ICT)
Economies of scale	Legislative and financial support for joint R&D activities in fragmented industries; supranational cooperation
Structure of the innovating industry	Effective anti-trust legislation to avoid monopolistic situations and patent legislation to provide incentives for private investment in R&D
R&D efficiency and effectiveness	Developing capacity to train researchers, improved management and organization of government research organizations
Adoption rate and speed	Improvements in extension, agricultural input and produce markets, infrastructure, credit, education, mass media, price policies, etc.
Risk and uncertainty	Political stability; clear policies on intellectual property rights, ethical standards, and other regulatory measures; capacity to predict future developments (e.g., foresight studies, scenarios)

Source: Roseboom (2003a, b)

4. An optimal level of investment in agricultural research and extension

A fixed target for the optimal level of investment in public agricultural research and public agricultural extension does not exist. There is no standard rule of thumb that can be easily applied across all countries. Actual research intensities steadily increase going from low-income to high-income countries as well as through time. Despite this positive growth in research intensity, there is a strong notion in the literature that there is considerable underinvestment in agricultural R&D. Hence, taking a benchmarking approach (i.e., comparing the research intensity score of each country against the income-group or regional average) would mean settling on a less-than-optimal score.

Instead, we suggest adopting a minimum agricultural research intensity target of 1% of agricultural GDP. Under normal circumstances (i.e., relative political and economic stability) and assuming a careful selection of research projects, countries should be able to make a good average return on such an investment (Roseboom 2002a, b and 2003b). This 1% is a lower bound estimate – depending on local circumstances and stage of development, profitable investment opportunities in agricultural R&D could be substantially larger. Nevertheless, roughly three-quarters of the developing countries (representing 90% of the population and agricultural output) spend less than 1% of their agricultural GDP on agricultural research and hence there is substantial room for additional investment.

The 1% target proposed here differs substantially from the 2% target proposed by the World Bank in the early 1980s (World Bank 1981). That 2% target was based on the investment level of the developed countries at that time. Applying the same rule today, would suggest an investment target of 2.5-3.0% of agricultural GDP. However, this recommendation is based on the assumption that developing countries face the same innovation opportunities as developed countries. In reality, the set of profitable innovation opportunities to choose from is substantially more limited for developing countries than for developed countries.

Hence, when the developing countries would have followed the advice of the World Bank, they would have substantially over-invested in agricultural R&D (i.e., selecting projects with very low or negative rates-of-return) (Roseboom 2002a, b and 2003b). So, rather than setting a, for most developing countries, unattainable and undesirable target, it is better to adopt a lower, but more realistic target and concentrate our investment efforts on those countries that lag behind.

In table 9 we have compiled agricultural research intensity ratios covering the period 1995-2000. The first two columns of the table report "mean" and "weighted" sample averages of agricultural research intensity ratios for the different regions and income groups. For the developing countries, the reported weighted averages are consistently lower than the reported mean averages, which indicates that small developing countries invest relatively more in agricultural research than big developing countries. For the developed countries, however, just the opposite can be noted. "Constructed weighted" averages were obtained by inserting estimated intensity ratios for those countries for which no recent intensity ratio was available. By multiplying the average value of agricultural GDP for the period 1995-99 with these intensity ratios, an estimate of the total amount of investment in public agricultural R&D was constructed (column 4).[7] Column 5 of table 9 reports the amount of money that should have been invested in agricultural R&D so that all countries spend at least 1% of their agricultural GDP. No adjustment was made for those countries that exceed the 1% target. Column 6 (the difference between columns 5 and 4) indicates how much more should have been invested in public agricultural research globally so that all countries invest at least 1% of their agricultural GDP in public agricultural research. For the period 1995-99, this would have been in the order of US$ 3.4 billion annually. The bulk of this additional investment requirement would go to low and lower-middle income countries. When divided by region, 71% of the

[7] The estimated figure is somewhat lower than the figure reported in the last column of table 1 for 1996. The difference is due to: (a) a somewhat smaller set of countries; and (b) a somewhat lower intensity ratio for Asia.

Table 9: *Estimated public agricultural research investments (1995-99) in comparison with a 1% intensity ratio target*

	Agricultural research intensity ratio			Agricultural research expenditures		
	Sample (mean)	Sample (weighted)	Constructed (weighted)	Estimated investment	All countries invest at least 1%	Additional investment needed
		(percentage)			*(million US dollars)*	
Subtotal developing countries (48, 104)[a]	1.31	0.61	0.63	4,593	7,939	3,346
Sub-Saharan Africa (16, 41)	0.91	0.66	0.64	563	1,011	448
Asia & Pacific (2, 20)	0.34	0.34	0.44	1,795	4,160	2,365
Latin America & Caribbean (24, 31)	1.81	1.17	1.16	1,527	1,723	196
Middle East & North Africa (6, 12)	0.65	0.64	0.71	708	1,044	336
Developed countries (20, 22)	2.23	2.57	2.57	11,356	11,438	82
Low-income countries (16, 47)	0.58	0.39	0.41	1,064	2,591	1,528
Lower middle-income: China (1, 1)	0.33	0.33	0.33	551	1,664	1,113
Lower middle-income: other countries (16, 33)	0.91	0.58	0.58	912	1,587	675
Higher middle-income countries (16, 24)	2.44	1.37	1.33	2,102	2,162	60
High-income countries (19,21)	2.33	2.63	2.62	11,321	11,339	18
Total (68, 126)	*1.58*	*1.48*	*1.36*	*15,949*	*19,343*	*3,394*

Note: Constructed on the basis of agricultural research intensity ratios obtained from the ASTI database. Agricultural research expenditures were estimated for each country by multiplying the average value of agricultural GDP for the period 1995-99 with the average research intensity ratio. Countries for which no recent intensity ratio was available an estimate was inserted based on region and income-group characteristics. The Asian sample is rather small (a new survey is underway), although the two countries covered are China and India.

[a] The first number represents the number of countries for which an intensity ratio was obtained, while the second number represents the number of countries for which an agricultural GDP figure for the period 1995-99 was available and which limited the number of countries for which an agricultural research expenditure figure could be estimated to 126. The data excludes the former USSR and Eastern Europe (as in the previous tables) as well as quite a number of very small countries. The latter group would not affect the reported expenditure figures much.

additional investment would go to Asia & Pacific (US$ 2.4 billion) and 54% to just two Asian countries: China and India (US$ 1.8 billion).

One of the problems of setting a minimum target for public extension expenditures as a percentage of agricultural GDP is that, going from low-income to high-income countries, extension expenditures grow more slowly than agricultural GDP. Assuming that the observed differences in extension intensity across countries at different stages of economic development follow some sort of economic rationale (but probably at some distance of what would be optimal), a minimum extension expenditure intensity target may turn against itself over the longer run and overshoot what is optimal.

Instead, we tried to model why extension expenditures can be expected to be relatively higher in poor countries than in rich countries. Based on the idea that face-to-face interaction is essential in order to diffuse knowledge (and this is particularly so in rural communities were the majority of farmers is illiterate and were modern media are not available), extension costs will depend largely on the number of people that needs to be reached. The minimum target we suggest to adopt is that of at least one extension agent per 1,000 agricultural labourers. In 1988, this ratio was in the order of 1,800-3,000 for the developing countries and around 400 for developed countries (table 6).

In table 10, we have applied this minimum target of one extension agent per 1,000 agricultural labourers across all developing countries and calculated for each country the corresponding expenditure figure assuming a fixed cost per extension agent that varies by income group. The outcome of this exercise is that, while applying the same target, the extension expenditure intensity ratios for sub-Saharan Africa and Asia & Pacific exceed the 1%, while for all other regions it is substantially lower. When differentiated by income group, the low-income countries and China (together representing 90% of the agricultural population in the developing world) really stand out as requiring a higher level of extension investment intensity than the other countries in order to achieve the same service level. Better education and better access to modern media substantially enhance the diffusion of knowledge. Additional investments in these areas would improve the effectiveness and efficiency of agricultural extension and (in the long run) reduce extension costs.[8]

Table 10: *Agricultural extension expenditures and intensity ratios to achieve a fixed service level of one extension agent per 1000 agricultural labourers, 1995-99*

	Agricultural labour	Expenditures needed to meet target	Intensity ratio	
			Mean average	Weigthed average
	(million)	*(million US$)*	*(%)*	*(%)*
Sub-Saharan Africa	175	894	1.78	1.02
China	511	2554	1.53	1.53
Asia & Pacific, excl. China	466	2475	1.19	1.02
Latin America & Caribbean	43	438	0.38	0.34
Middle East & North Africa	41	321	0.39	0.32
Low-income countries	600	2999	1.85	1.17
Lower middle-income: China	511	2554	1.53	1.53
Lower middle-income: other countries	92	737	0.52	0.47
Higher middle-income countries	33	391	0.35	0.27
Total developing countries	*1235*	*6681*	*1.15*	*0.92*

Note: Annual expenditures per extension agent were estimated at US$ 5,000 in low-income countries plus China, US$ 8,000 in lower-middle income countries, and US$ 12,000 in higher-middle income countries. Although we used a lower cost per extension agent figure, China's projected extension intensity ratio is exceptionally high. Still 70% of China's labour force works in agriculture, which looks rather high given its level of development.

Based on this exploration, we believe that a target of 1% of agricultural GDP to be invested in agricultural extension by countries in their early stages of economic development to be justifiable. At later stages of economic development, however, this percentage should decline rather than increase, for three reasons: (1) a sharp decline in the number of agricultural labourers per volume output; (2) other channels of knowledge diffusion become relatively more important; and (3) a shift towards funding by clients rather than public resources. Also Evenson (1986) considers an extension investment intensity of 1% of

[8] Evenson (1986) reports that there is a substitution relationship between extension and education, which means that the marginal impact of extension is lower the more schooling the farmers have received. This would explain the relatively lower investment in extension noted in developed countries.

agricultural GDP as the upper limit for well-functioning extension systems in developing countries.

In summary, focusing on those countries that are most severely affected by poverty and hunger (i.e, low-income and lower-middle income countries), an investment target of 2% of agricultural GDP in agricultural research and extension combined would be a reasonable and defendable target, which should bring the actual growth of the agricultural sector in these countries closer to its potential growth. There is, however, a limit to what agricultural research and extension can do in order to accelerate economic growth. The proposed target would result in roughly a doubling of public agricultural research and extension expenditures in low and lower-middle income countries (table 11). Since we have formulated our target as a percentage of agricultural GDP, this doubling comes on top of the 2-4% annual growth that is needed in order to stay in tune with the growth of agricultural GDP.

Table 11: *Additional investments needed to achieve 2% target*

	Actual expenditure	Additional expenditure	Total expenditure
		(million US dollars)	
Research			
Low-income countries	1,064	1,528	2,591
Lower middle-income: China	551	1,113	1,664
Lower middle-income: other countries	912	675	1,587
Total	2,527	3,316	5,842
Extension			
Low-income countries	1,539	1,026	2,565
Lower middle-income: China	829	917	1,746
Lower middle-income: other countries	891	594	1,485
Total	3,259	2,537	5,796
Total (research + extension)	*5,786*	*5,853*	*11,639*

Note: The actual extension intensity ratio was estimated at 0.60% of agricultural GDP across all countries for the period 1995-99, except for China for which we had an actual observation of 0.47%.

5. An international strategy to mobilize additional investment in agricultural research and extension

The global targets as set in the previous section are rather crude and general. The knowledge whether substantial additional investment in agricultural research and extension is justified is very much local and so the initiative and responsibility for the investment should lie with the national governments. The international donor community can assist and support national governments to raise their investments in agricultural research and extension, but is in no position to dictate investment levels.

Investments in agricultural research and extension are a long-term commitment. The financing of it should be primarily local and a high-level of donor dependency should be avoided. Too often research or extension projects and sometimes whole programs collapse because donor funding stops. Hence, the suggested fifty-fifty split between international donors and national governments in order to mobilize the additional investment is to be questioned seriously. Moreover, while the gap analysis in section 4 gave us an idea of the order of magnitude of additional investment needed in low-income and lower middle-income countries, it is not necessarily a good instrument to guide the allocation of international support. The question to ask is whether countries that severely under-invest in agricultural research and extension should receive more support than similarly poor countries that invest substantial sums of their own resources. In other words, do we want to place a premium on bad governance? We are not in favour of that and suggest to drop the gap-filling approach and to adopt a more equitable approach to support agricultural innovation in poor countries.

An international *matching budget support facility* for national agricultural research and extension, for example, would be substantially more equitable. Moreover, it would leave the initiative and responsibility for those investments with the national governments. For every x dollars that a government spends on agricultural research and extension this international facility would provide one dollar extra. The ratio between own investment and international support could be in the range of 3:1 to 9:1 and could vary according to income level. The higher the income, the lower the support provided by this facility. In the long run, however, countries should finance their own agricultural research and extension expenditures. The facility should have a time horizon of 20-25 years as well as a proper phasing out strategy.

The facility should work as a support mechanism for governments to invest more in agricultural research and extension. However, there will be a limit. When agricultural research and extension expenditures combined reach 2% of agricultural GDP no further support will be provided. This does not imply that further investment is not needed, but countries should do this without external support.

Rather than having separate matching budget support systems for agricultural research and extension, it would be better to have one facility and let countries themselves decide whether they want to invest relatively more in extension than in research or the other way round. The overall picture is that poor countries initially tend to invest more in extension than in research, but that that changes when they become richer.

Table 12 summarizes what the facility would cost annually, would it have been in force during the years 1995-99 and all low-income and lower middle-income countries had raised their investment in agricultural research and extension to 2% of agricultural GDP. The adopted support ratios are 4:1 for low-income countries and 9:1 for lower middle-income countries. The total international donor support required would have been in the order of US$ 1.8 billion annually. Given the fact that agricultural GDP grows with 2-4% annually, the total maximum cost of the budget support system would grow at a similar rate. However, a dampening effect can be expected from countries moving up to a higher income group and hence seeing their right to support reduced.

Table 12: *Estimated costs of an international budget support facility for agricultural research and extension, 1995-99*

	Agricultural GDP 1995-99	Target investment of 2% of AgGDP	International support
	(million US$)	*(million US$)*	*(million US$)*
Low-income countries (63, 55)[a]	266,042	5,321	1,064
Sub-Saharan Africa (37, 33)	80,756	1,615	323
Asia & Pacific (14, 11)	172,615	3,452	690
Latin America & Caribbean (2, 2)	1,726	35	7
Middle East & North Africa (1, 1)	1,448	29	6
Former USSR and Eastern Europe (9, 8)	9,497	190	38
Lower middle-income countries (47, 41)	359,521	7,190	719
Sub-Saharan Africa (4, 4)	673	13	1
China (1, 1)	166,393	3,328	333
Asia & Pacific (6, 6)	35,823	716	72
Latin America & Caribbean (16, 15)	32,724	654	65
Middle East & North Africa (11, 8)	87,511	1,750	175
Former USSR and Eastern Europe (9, 7)	36,336	727	73
Total (110, 96)	625,563	12,511	1,783

Note: The classification of countries by income group is based on World Bank (2001). The AgGDP data were also obtained from this source.
[a] The first number indicates the number of countries reported in this income category by the World Bank, while the second number indicates the number of countries for which agricultural GDP data was available to calculate the required investment level. Data are missing for some 14 countries, most of which are either small, at war, or politically unstable.

As shown in table 12, the bulk of the financial support would go to Asia, followed by sub-Saharan Africa, and Middle East & North Africa. Interestingly, the former USSR and Eastern Europe would be eligible for more support than Latin America & Caribbean.

The maximum amount that the budget support system would cost annually is US$ 1.8 billion. In its early years, however, the facility will cost considerably less (probably half) as countries will not be able to double their investment in agricultural research and extension overnight. It will take a considerable number of years before the set target will be reached. A doubling of expenditures in ten years time requires an annual growth rate of 7.2%. Another 2-4% annual growth needs to be added to keep at par with the growth of agricultural GDP. So in total, agricultural research and extension expenditures need to grow at around 10% per annum to reach the target in ten years time. This is a very ambitious growth rate and one may run into absorption capacity problems. It is more likely that the target will be reached considerably later in time. But it will be the national governments themselves who will decide on how fast they can catch up.

Perhaps a weak spot of the proposed scheme is that countries may start to cheat and charge all kinds of other expenditures against the research and extension budget. Some control mechanism is needed. Some cheating will be unavoidable, but the question to ask is whether it is substantially more than with other types of schemes or that the costs of minimizing cheating are prohibitively high (e.g., sending auditing teams). On the other hand the management costs of a matching budget scheme are low in comparison with most other types of support schemes.

The advantage of the budget support facility is that it can work as a leverage to increase national support for agricultural research and extension. What some donors may see as a disadvantage is that they cannot micro manage how the money will be spent, other than that it is spent on agricultural research and extension. All kinds of more specific desirable objectives, like reaching the poorest of the poor, women, marginal areas, etc., have to be negotiated at the local level. It is at the local level, however, where such decisions on priorities should take place and not in international donor circles. Nevertheless, international and bilateral agencies could assist national governments in improving their priority setting processes. The World Bank initiative on poverty-reduction strategies is a good example of national governments and the donor community developing joint strategies.

In addition to humanitarian considerations, the self-serving rationale for rich countries to support a matching budget support facility for agricultural research and extension (or for that matter any other support facility for agricultural research and extension in poor countries) is that it would help reduce the trans-border negative externalities of hunger and poverty such as war, terrorism, refugees, economic migration, and environmental degradation.

6. Organizing and financing agricultural research and extension at the national level

In most developing countries, agricultural research and extension is predominantly financed by general tax revenues and implemented by government agencies. Over the past 10-15 years, however, there has been a considerable move to organize and finance public agricultural research and extension differently. This drive for change has been based largely on *new public management* (NPM) ideas and concepts. The NPM School aims to foster a performance-oriented culture in a less-centralized public sector and has strongly influenced public sector reforms all over the world during the past 15-20 years. Although NPM has often been associated with antigovernment sentiments, it is more concerned with improving the performance of the public sector rather than with reducing the role of government. NPM reforms usually comprise six core characteristics:

1) *Productivity*: finding ways of generating more services from the same or smaller revenue base;
2) *Marketization*: contracting out the implementation of policies to the private sector or to semi-autonomous, non-profit agencies and replacing traditional bureaucratic command-control mechanisms with market strategies;
3) *Service orientation*: making government programs more responsive by changing the focus of the service delivery system. Instead of designing programs from the point of view of service providers and managing them through existing bureaucratic structures, reformers are trying to put citizens (as service recipients) first;
4) *Decentralization*: transferring more service-delivery responsibilities to local governments and front-line managers;
5) *Policy*: separating government's role as a purchaser of services from its role in providing them; and

6) *Accountability for results*: focusing more on outputs and outcomes instead of processes and structures. Replacing top-down, rule-based accountability systems with bottom-up, results-driven systems (Kettl 2000).

Australia, New Zealand, Great Britain, and the Netherlands have been pioneers in adopting NPM approaches to public management. More recently, however, also many developing countries have adopted NPM ideas and concepts in order to improve the performance of the public sector, including the delivery of agricultural research and extension services.

Key characteristics of agricultural research and extension reforms in recent years and very much reflecting the NPM agenda are:

1) A redefinition of the role of government in the provision of agricultural research and extension services. Usually this led to a separation of funding, priority setting, and implementation roles and a stronger emphasis on accountability.
2) Decentralization of agricultural research and extension services not only in terms of physical location, but also in terms of decision making. Frontline managers in direct contact with their clients and stakeholders are given more responsibility.
3) Improved service orientation: farmers to be treated as clients and stakeholders and not as passive beneficiaries. Direct involvement of farmers in priority setting, implementation, and evaluation of extension and research services.
4) Outsourcing of the implementation of agricultural research and extension services to private non-profit agencies and (although to a lesser extent) to private for-profit companies.
5) A stricter application of the rule that those who benefit should pay; in some instances this may lead to a complete privatization of certain research and extension activities

(e.g., export commodities), while in other instances shared funding arrangements may be a called for.

Much of the reform debate in agricultural innovation focuses on the privatization of agricultural research and extension services. There are heated debates about the desirability of this development and in particularly so because some governments just abandon public agricultural research and extension activities without properly considering its public-good character. Similarly, however, one can find stout defenders of the public good that are basically defending private interests. Table 13 very schematically depicts contrasting combinations of financing and implementation of agricultural research and extension. The classic public-private dichotomy is that of public sector agencies financed by general tax revenues (box A) versus private-for-profit companies selling services to private individuals (box I). The traditional view is that agricultural research and extension activities belong in box A. The agricultural research and extension reforms, however, argue (backed by NPM thinking) that other modalities of service delivery and financing may be desirable under certain circumstances and that a diversification of financing and implementation modalities is to be promoted. For example, not all agricultural research and extension services have an equally strong public-good character. When services lead to significant private benefits to specific groups or individuals, more specific financing instruments may be warranted like specific taxes or levies, or individual payments. Such sources of funding are not uncommon in public agricultural research and extension agencies (boxes B and C) but usually relatively small. By screening agricultural research and extension activities more strictly for their public-good character, public resources could be freed up and used for truly public-good activities (including agricultural research and extension activities with a strong public-good nature) or tax reduction.

Table 13: *Privatization of service implementation versus financing*

		Financing source		
		General tax revenues (public goods)	Specific taxes or levies (common pool goods)	Individual payments (toll or private goods)
Agricultural research and extension implementing agencies	Public sector: Ministry departments; Autonomous public agencies; Commodity boards	A	B	C
	Civil society: Farmer organizations, NGOs, etc.	D	E	F
	Business sector: Private-for-profit companies	G	H	I

When comparing agricultural research and extension services, the excludability of service delivery seems to be relatively stronger for extension than research. As a consequence, private financing of agricultural extension (as well as private delivery) seems to take off faster and to go further than the private financing (and delivery) of farmer-oriented agricultural research.[9]

The other opening that the NPM School of thinking created is that public-good delivery is not the exclusive domain of government bureaucracies. The delivery of "public-good" agricultural research and extension services can be contracted out to autonomous public agricultural research and extension agencies (box A), to civil society organizations like farmer organizations and NGOs (box D), or to private-for-profit companies (box G). It is important to realize that the character of the implementing agency does not necessarily define the character of the services delivered. This diversification towards other implementing agencies requires important institutional changes, such as a clear separation between policymaking and implementation roles within the Ministry of Agriculture and the introduction of contracts between the policymaking entity and the implementing agency. The latter could even be a ministerial department, but no longer managed on the basis of a bureaucratic command structure but on the basis of market-type contract arrangements that

[9] Not considered here is the private and usually intramural research conducted by agricultural input and processing industries.

specify expected outputs. This implies a complete change in the incentive structure and requires an enormous change in organizational culture (Chapman and Tripp, July 2003).

Competitive funding schemes for agricultural research and extension very much represent typical NPM thinking and have been widely promoted by international and bilateral donors in recent years. In quite a number of developing countries experiments with competitive funding schemes for agricultural research and extension are underway, although usually on a rather small scale. While it is perhaps too early to evaluate the effectiveness and efficiency of competitive funding schemes, the first reviews suggest considerably less positive gains than expected (Gill and Carney 1999; Brinkerhoff *et al* 2002).

Matching grant schemes are another financing instrument promoted by the NPM School, but surprisingly little applied to agricultural research and extension.[10] The only notable and well-documented exception is the introduction of a matching grant scheme for agricultural research in Australia in the late 1980s and early 1990s (Alston *et al* 1999). A matching grant scheme is particularly relevant when the benefits of the investment are neither strictly public nor strictly private. This applies to most agricultural research and extension activities. Rather than pushing these activities either in an exclusive public or private financing category, joint public-private financing of service delivery is being pursued. One of the great advantages of matching grants is that the clients and stakeholders are directly involved in setting service delivery priorities. In some countries, matching grant facilities are also used to mobilize financial support from local governments (districts, provinces, states). For every x dollar invested by the local government, the central government adds another dollar.

The introduction of user fees is an important development in the financing and organization of public extension services in quite a number of countries. In many instances

[10] Some implicit use of matching funding does exist in situations were the government pays for the salaries and the private sector for the operating costs of specific research activities.

such fees only recover a small part of the costs. Their advantage, however, lies in that they signal demand and are seen as an effective instrument to steer the supply of public extension services. This was also one of the ideas behind the introduction of a government-funded voucher system for agricultural (extension) services in Chile during the period 1978-85. Farmers would determine the type of advice that they need and select the best provider in the market. However, it did not work as expected because of lack of alternative suppliers in most rural areas and the scheme was discontinued (Berdegué and Marchant 2002).

7. Research and extension priorities

While arguing that local governments should set their own priorities for agricultural research and extension, the international development community has identified two important priority areas for public agricultural research and extension, namely: (1) poor farmers in marginal areas (this is in line with the strong international emphasis on poverty reduction); and (2) sustainable management of natural resources (i.e., the Rio and Johannesburg conferences).

It is generally believed that public agricultural research and extension investments benefit in particular the richer farmers in the better agricultural areas. Being better educated, healthier, and controlling more resources, they are in a better position to absorb new knowledge and technology and exploit it. They are just the better clients of extension and research services. Moreover, they use their political cloud to get research and extension projects selected that are particularly beneficial to them (de Janvry *et al* 1989). The current strong emphasis on client orientation and stakeholder participation in agricultural research and extension reforms are very likely reinforcing this, since the richer, commercial farmers are usually better organized than the millions of poor subsistence farmers. Equitable processes do not necessarily produce equitable outcomes (Hood 1998). Assuming that innovation projects that benefit the poor and disadvantaged are relatively discriminated against in priority setting processes, a stricter adherence to economic selection criteria should benefit the poor (Roseboom *et al* 2003).[11] A logic subsequent step would be to introduce positive discrimination and argue that an extra dollar earned by a poor farmer is worth more than an extra dollar earned by a rich farmer. Roseboom *et al* (2003) show that, even with a premium of a 100% on the benefits of research projects that benefit poor farmers (assuming that we can identify them as such), the income redistribution effect is relatively small as well as the economic welfare loss. It reaffirms a popular opinion among economists that agricultural research is not a very effective equity instrument. The baseline problem is that the set of profitable innovation opportunities from which to choose (i.e., projects with a sufficiently high expected rate of return) is much smaller for poor farmers than for rich farmers and for marginal lands than for the best agricultural lands.

The unprecedented population explosion the world has experienced during the 20th century has taken an enormous toll on the natural environment and has raised major concerns about the sustainability of our agricultural production systems. Increasingly the negative externalities of our actions are being felt in terms of pollution, erosion, global warming, and a rapid reduction in biodiversity. These issues transcend national borders and environmental sustainability has become a global issue. However, long-term sustainability often conflicts with short-term profitability and in many instances also with short-term survival. One of the major problems in agricultural research priority setting is how to price and evaluate the costs and benefits of research on sustainability issues. Similarly, how can we capture the negative externalities of proposed new technologies in ex ante evaluations and make better-informed decisions?

In the end of the day, the ultimate objective of priority setting is to select the most promising agricultural research and extension projects in terms of creating additional wealth

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[11] Another, equally important option is to help poor farmers to organize themselves so that can more forcefully lobby for their own interests in priority setting processes.

and income, within the constraints of sustainability, food security, and poverty reduction. In this light, many countries see an important role for public agricultural research and extension to help farmers to diversify into high-value-adding activities that generate income and foreign exchange.

8. Conclusions

The significant role of public agricultural research and extension in enhancing agricultural production and productivity is well documented. Nevertheless, in many developing countries agricultural production and productivity growth has been insufficient to eliminate hunger and extreme poverty. This problem can be tackled by a twin-track strategy: (1) A more equitable distribution of food and income; and (2) A higher volume of agricultural output produced in a more sustainable manner. Both strategies should be pursued simultaneously.

Supported by economic impact studies that report on average high rates of return, there is a widely shared opinion that there is considerable underinvestment in public agricultural research and extension. In other words, the potential of agricultural research and extension in enhancing agricultural productivity and production is not being exploited fully. At the same time, however, there is also considerable spillage, suggesting that more impact can be achieved with the same resources. The ongoing reforms in agricultural research and extension, which have been strongly influenced by NPM ideas and concepts, are attempts to improve the efficiency and effectiveness of these services. This is a permanent struggle as each organizational model has its own limitations, which eventually become stumbling blocks for further progress (Hood 1998).

The question that this paper tries to address is how much more developing countries could invest in agricultural research and extension without overshooting their target. Based on theoretical considerations as well as common sense, this paper sets a minimum expenditure target for low-income and lower middle-income countries of 2% of agricultural GDP for public agricultural research and extension combined. For these two groups of countries, comprising the overwhelming majority of the rural poor in the world, this would mean roughly a doubling of investment in public agricultural research and extension and would require (based on 1995-99 figures) an additional investment in the order of US$ 5.8 billion annually.

Such an increase in investment cannot happen overnight, but will take at least a decade if not more. The financing of this additional investment should be largely local in order to avoid the typical pitfalls of being too dependent on erratic donor support. The international donor community, however, could assist constructively by setting up a matching budget support facility for public agricultural research and extension for low-income and lower middle-income countries. For every x dollars spent on public agricultural research and extension, this facility would provide an extra dollar. It gives national governments in poor countries an incentive to increase their investments in agricultural research and extension. The ultimate investment decision, however, will be taken by national governments as they best can judge whether additional investment in agricultural research and extension is warranted.

While the content of public agricultural research and extension activities will vary across countries (depending on the local situation and production systems), the international donor community has identified two major, overarching priority issues for public agricultural research and extension in developing countries to address, namely: (1) A stronger and more explicit focus on poor and disadvantaged farmers in marginal areas; and (2) A stronger contribution to the reduction of negative externalities of agricultural production (such as pollution an depletion of natural resources). A better understanding of political decision making processes is needed in order to understand why these issues apparently do not get the attention they require in many countries and stimulate thinking and debate of how priority setting processes at the national level could be improved so that they create a more balanced outcome.

Finally, investments in agricultural innovation can only prosper in an enabling environment. Political and economic stability are important preconditions, while investments in education, health, rural infrastructure, and markets may substantially enhance innovation opportunities and hence increase the attractiveness of more investment in agricultural innovation.

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