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OECD Development Advisory Committee
Poverty Network Publication

"Enabling Pro-Poor Growth through Agriculture"

Chapter 12. Revitalising Investments in Science and Technology for Pro-Poor Agricultural Growth[1]

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[1] The paper was drafted by Simon Hocombe with input from Ahmed Sidahmed, Rodney Cooke and Susan Thompson and participants of a group discussion of some Rome based experts (IFAD/USAID).

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Acronyms

CGIAR	Consultative Group for International Agricultural Research
DAC	Development Advisory Committee
GEF	Global Environmental Facility
GFAR	Global Forum on Agricultural Research
GM	Genetic modification
IFI	International Financing Institution
ILAC	Institutional Learning and Change
IPM	Integrated Pest Management
M & E	Monitoring and Evaluation
MAPP	Multi-country Agricultural Productivity Programme for Africa
MDG	Millenium Development Goals
NARS	National Agricultural Research Systems
NEPAD	New Partnership for Africa's Development
ODA	Overseas Development Assistance
PBAS	Performance-based Allocation System
PRS	Poverty Reduction Strategy
R & D	Research and Development
RW	Rural Worlds
S & T	Science and Technology
SAP	Structural adjustment programme
T & V	Training and Visit Extension

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Draft Chapter 12. Revitalising Investments in Science and Technology for Pro-Poor Agricultural Growth

I. Introduction: the Aims and Limits of Chapter 12

1. This draft covers one chapter of a DAC Poverty Network policy document that is currently under preparation for the OECD entitled *Enabling Pro-Poor Growth through Agriculture*. It is aimed at senior decision makers in the OECD countries that are sources of overseas development assistance (ODA), and at ministers and other influential figures in the finance, planning and technical ministries of recipient developing countries. An outline of the complete document is given as Annex 1. Earlier chapters will deal with the need for a new agenda, priorities and securing opportunities for pro-poor growth. This chapter, on science and technology, is one of four on revitalizing pro-poor investments: the other three refer respectively to reinforcing human capital, infrastructure, and access to the resource base. A proposed final section will set out a new agenda and its implications for pro-poor growth. The document as a whole aims to re-focus assistance for agriculture more precisely on achieving the MDGs.

2. The starting point for investments in pro-poor science and technology is the need to promote agriculture that is sustainable, and based on technologies that are people-friendly and adoptable by, or create new livelihood opportunities for, the poor and disadvantaged. However this chapter is *not* intended to prescribe technologies *per se*. Those that are cited are intended only as examples. Instead it aims to guide on what governments, lenders and donors should do to use scarce agricultural development resources to the best benefit of the rural poor. It seeks to answer questions such as

- Why do we need to invest in agricultural science and technology for the poor?
- How should we decide for whom, in what, where, and with what priorities to invest?
- To what global changes should we be responding?
- Who are the main stakeholders at different levels of the research and development continuum?
- What modes of organisation and operation of research and development are appropriate to present and future needs?
- How can the capacity to respond to these technical and operational challenges be augmented or created?
- How can we best evaluate the impacts of these investments and learn from their outcomes?

Finally it seeks to characterise the sorts of investment needed to turn suggestions into pro-poor actions, along the lines implied by the responses to these questions.

II. Science and Technology Beyond the Green Revolution: Emerging Challenges

3. Technical change is central to agricultural progress. If farmers were not experimenters and innovators, most of humanity would not be alive today. Farmers consider technical changes as they become aware of new pressures and opportunities; but act only when they judge that circumstances permit a safe and advantageous response.

4. The most recent and spectacular example of mass technology change in developing countries was the Green Revolution. It showed that even the poorest Asian wheat and rice farmers would adopt input-intensification technology provided that supplies of productive resources (irrigation water, seeds, fertilisers) were adequate, cost/price regimes and the social setting were conducive, and they judged risks to be acceptable. Progress was helped by good access to markets and favourable national economic policies, including regulated markets and carefully targeted ("smart") subsidies. Intensification technology packages were initially adopted by better-off farmers but later taken up by a mass of smaller producers, and eventually benefited even the landless through job creation and the multiplier effects of growth within rural economies. Only recently has progress stagnated, due mainly to land degeneration under the input management systems that were promoted.

5. Regrettably, for most small-scale farmers in much of the developing world and especially in many African countries, the pre-requisites for an input-based Green Revolution are absent. Much effort has gone into promoting input intensive packages amongst these farmers but uptake has been limited and often confined to the better-off. The public extension systems intended to further spread intensification were consequently perceived by the budgetary authorities as failing to justify their creation, and many collapsed in the face of budget cuts made as part of the Structural Adjustment Plans (SAPs) of the 1980s. Today it is the marginalised rural people in such countries who make up the majority of the world's poorest. The constraints to which they are subject include restricted access to land, risk-reducing irrigation and other natural resources; lack of inputs and money to acquire them; lack of markets for their products; cost/price regimes which make input-based intensification or diversification unprofitable; unfair competition from imports (1,2) and social constraints posed by gender, age or pressures to conform with peers or external influences. Since the poorest tend to be pushed by rising land pressure to the most marginal areas, such parcels of land as they have will be diverse, scattered and of variable quality. They will tend to be concentrated in places with greater natural risks. Furthermore, among these rural poor farming will often be only one among several strands in the livelihood strategies of the family; they may not perceive any changes in agricultural technology as either useful or relevant.

6. The many and varied non-technical constraints to pro-poor growth are described in detail in other chapters. The networks of constraints and opportunities to which different categories of rural people are subject can be conceptualised (3,4) as creating 'Rural Worlds'. These range from RW1 – capital intensive commercial farmers – through mixed commercial/subsistence farmers (RW2),

to the near or totally landless (RWs 3 and 4), and those who are unable because of gender, age or sickness to enter any economic activity (RW5).

7. The constraints which prevented so many of the rural poor from benefiting from the Green Revolution also, for the most part, impede their participation in three more recent waves of technology change (which can also be considered as technology "revolutions" of a sort) that are fast transforming agriculture and the food industry globally. These include the shift to new, knowledge intensive, systems that combine more efficient use of inputs with more sustainable management of the natural resource base – exemplified by reduced/zero tillage systems, organic farming and integrated pest management; exploitation of various aspects of biotechnology including genetic modification; and the revolutions in food products and retailing being spearheaded by supermarkets in response to increased global urbanisation and wealth combined with stricter government regulation (5). The last set of changes poses particularly acute problems of entry for the small farmer seeking to take advantage of the potentially higher earnings from diversification into such markets. Poor quality of staple crops such as rice may lead to a mark-down in the farm-gate price. But supermarkets and their customers demand such high standards of uniformity, maturity, volumes of delivery and guarantees of origin and production practices for the products they sell that even if only one of these demands is not met the small farmer's whole harvest may be rejected.

8. For the rural poor in developing countries, the urgent need is for science and technology to seek adoptable alternatives to the Green Revolution, as well as means to benefit more from these more recent, ongoing, tides of change in global agriculture. For the poorest, in RWs 3, 4, and 5, choices will have to be made between facilitating entry to commercial production where feasible and using higher cash incomes to improve livelihoods; easing their exit from agriculture in situations without opportunities for improvement; or upgrading technology for staple crops where the poorest still retain some land, but need to minimise livelihood resources used for subsistence. It will also be essential to further exploit opportunities to improve the circumstances of these inhabitants of RWs 3, 4 and 5 through job creation and the multiplier effects of further intensification and diversification in RWs 1 and 2. The very diversity of these possible solutions, and their specificity to different categories of poor people and locations, poses a further challenge to those setting priorities and making investment decisions.

III. The Rationale for Increased Investment in Pro-poor Science and Technology

9. Conducive public policies, effective government institutions and public goods technologies are essential to provide enabling conditions for rural growth. Investments can make the means through which the poor – by one or another of the routes in the previous paragraph – can share in the fruits of growth and countries can approach the MDGs. However public investment in rural development and agriculture, as well as overseas development assistance, declined sharply in many developing countries from the early 1980s.

Box 1

Trends in Government Expenditures and Overseas Development Assistance to Agriculture in Developing Countries (*Source: Jean –Philippe Audinet and Sappho Haralambous (2005) :An IFAD Policy paper: Achieving the MDGs: Rural Investment and Enabling Policy for IFAD Governing Council Panel Discussion – 16-17 February 2005 Rome Italy)*

FIGURE 3
Amount of government expenditures for agriculture per rural capita
USD 1995
(Source: Fan and Rao, 2003)

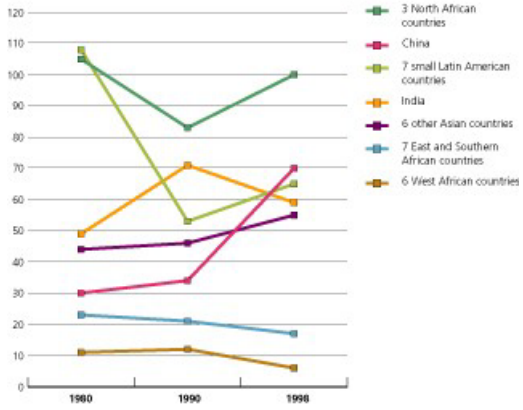
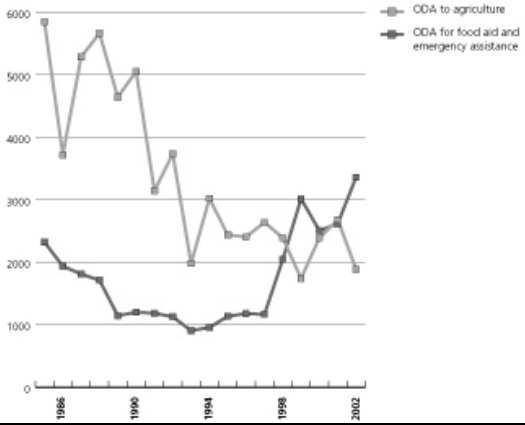


FIGURE 4
ODA for agriculture and ODA for food aid and emergency assistance, all donors to LDCs and other low-income countries
USD million, 2002 prices
(Source: OECD)



10. A recent IFAD paper (8) provides telling statistics on the impact of such changes on rural poverty. Box 1 shows that in a sample of Asian countries the falls in government agricultural expenditure per head of rural population have recovered somewhat from the lows of the 1980s and had risen to levels of USD 50 to 100 per head by the late 1990s; here progress is being made towards the MDG for poverty reduction. In Sub-Saharan Africa, in contrast, expenditures per head have continued to fall from generally USD 10 to 25 per head in the 1980s to as low as USD 5 in 1998; there rural poverty remains acute and widespread.

11. Many OECD countries, notably the USA, Japan and members of the EU, allocate the largest proportion of their public resources to agriculture – often at amounts of subsidy per producer that dwarf the levels of support handed out even in the richer developing countries. In developing countries the 1998 averages for allocations of government expenditures to agriculture varied by region from only 5% up to 10% -- a decrease from 6% to 15% depending on region in 1980 (9). And for a sample of six West African countries, public expenditures on agriculture averaged only 1.7% of total expenditure – equivalent to under USD 10 per head of population. Furthermore, while developed countries' support to their own agriculture has remained relatively stable since the 1980s, their overseas development assistance to agriculture in developing countries, while it stabilised during the late 1990s, remains at approximately half the level of the 1980s. Following this decline there has been an ominously sharp rise in needs for overseas emergency assistance to developing countries, particularly between 1998 and 2002: in 1999, for the first time, emergency assistance exceeded development assistance (Box 1). Only since 2000 have heads of state, in a series of declarations and with the backing of lenders and donors, committed themselves to allocate to agricultural development levels of finance that are more

consistent with the importance of agriculture to their economies, the needs of rural people and alleviation of poverty.

12. In contrast with the grim reminders of the consequences for rural people of funding decline, there is ample evidence of the benefits obtainable from carefully planned and executed rural investments. Data in Chapter 11 for China and Uganda (9) show that among various rural investment categories agricultural R&D generally gives the highest benefits, with 8 to 15-fold returns per unit of expenditure. R&D investment is usually also the most cost-effective route to reducing the number of people living in poverty.

Box 2
Returns to Rural Investment: India State-level Analysis

	Returns in Rupee Per Rupee Spending	***No. of Poor Reduced Per Million Rupee Spending***
R & D	**13.45**	**84.5**
Irrigation	**1.36**	**9.7**
Roads	**5.31**	**123.8**
Education	**1.39**	**41**
Power	**0.26**	**3.8**
Soil and Water Conservation	**0.96**	**22.6**
Health	**0.84**	**25.5**
Anti-Poverty Programmes	**1.09**	**17.8**

Notes: Marginal Returns are calculated for 1993
Sources: FAN, Hazell and Thorat, 2000

13. The CGIAR (10) reports average returns of USD 9 for each dollar spent on its research programmes. Numerous academic studies also flag the high economic returns derived from agricultural R&D (latest refs. needed). As Box 2 also shows, although categories such as rural access roads and education also gave high returns, sectoral impacts from agricultural R&D generally exceeded those from all other categories of rural investment.

14. The need for more rural investment is now increasingly recognised; however experience shows that the benefits of incremental investments will be jeopardised unless they are coherent and sustained. In the past many externally funded science and technology projects focused on objectives considered of particular interest to the funding agency. They lacked clear relevance to national Poverty Reduction Strategies (PRSs) or coherence with wider plans for rural development. They did not necessarily take into account whether there was a national comparative advantage for the production or processing activities to be encouraged, nor whether markets were accessible and profitable to producers. Needs for prior or parallel facilitating investments – e.g. in human resources development to increase local capacities for implementation or for rural infrastructure – may also not have been adequately considered. When superimposed on local implementing organisations weakened by budget cuts under SAPs, the impacts of such investments have been ephemeral. In such cases the end of disbursement brings with it the risk that new facilities will degenerate for lack of sustainable funding for operation and maintenance. National scientists may sink back into demoralised inactivity when salary incentives and mobility allowances cease.

15. Welcome steps have now begun to exploit in a more coherent and sustained way the opportunities for poverty alleviation provided by investments in agricultural science and technology. Major lenders such as the World Bank and some senior political figures from developing countries have in recent years committed themselves to reversing the declines in pro-poor agricultural investment. Donor alliances such as the Global Forum for Agricultural Research (GFAR) and the Multi-country Agricultural Productivity Programme for Africa (MAPP) under NEPAD provide effective means to integrate the support programmes they fund with national strategies for poverty alleviation. It will still be essential, however, to avoid overlaps between these new initiatives, and to ensure that efforts focus on topics coherent with national strategies for poverty alleviation, technical potentials and comparative advantage.

IV. Learning from Poor Farmers

16. There is now ample evidence that a farmer-centric approach is essential for the effective application of science and technology investment funds to help alleviate poverty among highly-constrained communities, families and individuals. From the outset the designers of investment support at field level need to align their plans for technology adaptation, testing and dissemination with four guiding principles that arise out of the circumstances, thinking and behaviour of the rural poor themselves.

- *First*, encourage and build on the propensities of farmers and other rural people to extemporise and experiment. "Modern" – i.e. conventional, reductive – science is an essential complement to their own knowledge and creativity but should not impose outside ownership on their own ideas. Innovations perceived as locally generated and owned will spread more quickly; news of them will pass rapidly through the normal rural information channels – which are from farmer to farmer or individual to individual.
- *Second*, before seeking to add novelties, investment programmes should help poor people in all RWs to make the best use of existing, available productive resources. Priority should go to applying known assets and technologies to better effect and reducing losses. Many of the rural poor live in areas with moderate or even high potentials for greater productivity, especially in Africa (6). Losses may currently consume half of output, yet loss minimisation tends to be an under-researched topic (7). Making better use of what the poor already have can, for example, span optimising productivity of the family labour or cash already committed to agriculture; exploiting biological/natural processes to enhance fertility or suppress pests, weeds and diseases; improving the capture of available rainfall; exploiting opportunities for on-farm storage or processing to add value; or no-cost changes (in terms of cash expenditure or use of family labour) to existing cropping patterns and rotations.
- *Third*, where technical change is proposed or additional resources are to be committed to agricultural activities, start from the familiar and minimise additional commitments to those needed to achieve acceptable gains. Help the poor to "do without as much as possible and still get away with it", as they – along with the rest of humanity – will always tend to do.
- *Fourth*, accept, and cater for, the inevitable diversity of target groups of the poor. Design science and technology investments to respond to the contrasting needs and levels of achievement that can be expected from inhabitants of the different Rural Worlds, taking into account their other options for livelihood improvement. Anticipate differentiated

responses, and at times rejection of technology change, depending on individual circumstances.

17. These principles are hardly revolutionary – but many past attempts at technological approaches to poverty alleviation have not recognised them and have sought to replicate a Green Revolution or promote other forms of market-dependent intensification in unsuitable settings. Faced with potential costs or risks that they found incompatible with their livelihood strategies, farmers rejected the full-package approach.

18. Nevertheless, although many of the areas occupied by the rural poor may be perceived as too risky for package-based, conventional intensification, farmers themselves often recognise the lesser opportunities for more gradual and progressive technology change. Even in well-endowed areas they may dismantle recommended technology packages and make their own experiments, testing only some of the contents at first – thus building their own "ladder" of technology which they climb only as fast, and as far, as their specific constraints and opportunities allow (the third guiding principle above). A similar approach is essential in areas with more moderate potentials. Further steps will be taken only as existing constraints are eased, new assets (such as education) accumulate or new opportunities (rural access roads, markets, demands for new products) arise.

A new smallholder-centred framework for investment in science and technology

19. These findings have led to a new framework for future investments in science and technology that have as their primary aim the alleviation of rural poverty. The framework shifts the past emphasis on technology *supply by scientists* to a system that responds to *user demand*. It links the search for new technology much more closely to efforts to resolve non-technical impediments to change. It fosters *equal partnerships between scientists and rural people* in the search for technologies adapted to the needs of the different RWs. It recognises and provides for *diversity* between RWs in needs and solutions. It is *multidisciplinary* in its approach to constraint identification and alleviation; it *widens stakeholder participation* to engage the contributions of those concerned with the many non-technical constraints to poverty reduction flagged earlier and discussed in detail in other chapters. It favours the emergence of *knowledge-based* optimisation in the use of available resources. It allows for *progressive* technical change or upgrading based on experiment and learning by poor people themselves. It focuses the use of public funds on the generation and dissemination of *public goods technologies*, but with *government agencies as facilitators* rather than masters of development.

20. The new framework *empowers rural communities* by giving them access to public funds to hire those service providers best able to support participatory stakeholder efforts, and to form alliances that will draw in complementary funds from the voluntary and private sectors. The new framework has the empowerment of rural communities and specific common interest groups within communities as the centre and starting point of efforts to relieve rural poverty. Without investments to strengthen the capacity and opportunity for poor people to direct, manage and control their own circumstances, future investments in technology will be of no more value than those of the past. Achieving empowerment means providing poor rural people with support to develop the knowledge, skills and organizations they need to access resources and services,

negotiate with private sector market intermediaries, and influence government policies and investments.

21. Governments have a critical role in financing the support needed for smallholders or rural communities to establish their own institutions – for example, farmers field schools for accessing and evaluating new agricultural technologies; village banks and rotating savings and credit associations for accessing financial services, and so building informal sector micro-enterprises; water users associations to manage irrigation infrastructure; or farmer enterprise groups or associations to negotiate with market intermediaries. Empowerment needs to be central to all initiatives that seek to harness science and technology to alleviation of poverty.

22. The new framework is very different from that which generated the successes of the Green Revolution. It is summarised in Table 1, which compares the past investment approach with the changes so far being applied to investments in science and technology R&D, and the needs for the future to further enhance effectiveness in bringing relevant technology to the poorest.

Table 1: Past, Present and Future Approaches to Investment in Pro-Poor Agricultural Science and Technology

INVESTMENTS THEN	INVESTMENTS NOW	INVESTMENTS IN THE FUTURE
1. Use extra inputs/cash/labour as necessary to raise yield.	Optimise returns to the critical items and accept whatever overall gains result.	Optimise returns achieved via more equitable access of smallholders to inputs, labour ,cash, etc
2. Scientists are the main source of ideas and knowledge for progress.	Stakeholders pool ideas: scientists are partners whose ideas and knowledge are additional to those of other stakeholders.	Maintained; also smallholders become major and critical contributors of ideas for the stakeholders' pool
3. Packages are designed, upstream, for wide, uniform, dissemination.	Stakeholders dismember/adapt packages and pool ideas to match local and individual circumstances.	Packages developed by stakeholders through full participation, in response to local demand
4. Implicit assumption that agriculture is the only path to improved rural livelihoods.	Recognises that other livelihood choices may be more attractive despite successful technology change.	Maintained; acknowledges that the number of smallholders in the rural communities will stabilise or decline with progress in education, communication and alternative livelihoods, and that a major share of agricultural products will be produced by increasing large scale farming.
5. Progress needs more cash expenditure	Progress is achieved via building location-specific knowledge and farming skills	Maintained; acknowledges that progress in poverty alleviation is increasingly influenced by the evolving expectations and circumstances of poor smallholders.
6. Getting cash depends on adopting a pre-defined package.	Adoption is progressive (a "staircase" or "ladder"); finance is not conditional.	Maintained; also acknowledges that adoption that is directly responsive to demand, is enhanced by poverty reduction strategies sensitive to circumstances of the poor.
7. Scientists evolve, test and promote technology change on the basis of their own results.	Farmers participate in choices of technology through their own experiments and are the main channels for dissemination once adoption is in prospect.	Smallholders participate in **generation** of technology through close and flexible partnership with the scientists.
8. Technology is considered adoptable, and is promoted, if returns on extra expenditure are sufficient.	Technology becomes adoptable, therefore is disseminated by farmers, only if upstream and downstream constraints permit.	Technologies **developed** to be adoptable, through partnership between scientists and the smallholders who share the common goal of rural poverty reduction.

9. Introduction of technical novelty (agrochemicals, germplasm, machines etc.) is the principal aim and usual starting point for technical innovation.	Better use or management of what is already to hand is the starting point and main focus.	Maintained; also new technologies are demand based, generated by collaborative research and require minimum burden to smallholders time and resources.
10. Technology should "sell" solely on the financial returns to the adopter, who should pay the full costs of uptake and use.	If new technologies generate benefits to society at large or for future generations, public funds are justified to support their introduction.	Partnership between private and public sectors common. The private sector is contracted to research and develop technologies that are public goods, realising common benefits from poverty reduction and a healthy rural economy.
11. Public research and extension organisations are largely autonomous parts of sectoral or technical ministries and set their priorities accordingly.	Public sector support for technology change is conceived and funded as part of wider poverty reduction or rural development programmes: priorities are linked to wider social and economic needs.	Maintained; also extension and technology transfer flow directly from technology generated through farmers' own participation in research.
12. Public sector funding drives technology change.	Public sector funding facilitates stakeholder partnerships and levers the contributions of farmers, voluntary and private sectors.	Maintained; public sector funds are catalytic and regulatory aiming to promote bio-safety, food quality, food safety and environmental welfare.
13. High potential profitability justifies public financing of R&D; public and private sectors duplicate or compete in efforts towards technology change.	Public finance aims only to stimulate the flow of "public goods" technology, from other stakeholders where they are willing; it focuses on complementing private initiatives and filling gaps relevant to the poor and others who cannot pay.	Maintained; also public funding aims to enhance responsibility sharing by all stakeholders in developing and assuring equitable access of the rural communities to the "public goods" technology

VI. Science and technology for pro-poor agricultural growth: examples

(a) Some current trends

23. What are some of the specific technical changes that currently have the potential to reduce rural poverty? Once again, the clues come from the farmers themselves. Non-technical factors and constraints will always influence the extent to which technical change is possible in a given setting; opportunities for pro-poor change will vary widely between geographic regions and agro-ecological zones (6). But given necessary support and in the absence of overriding non-technical constraints, various pro-poor technologies are already gaining ground in rural communities, even in resource-poor settings. In hesitant ways, and to differing degrees, poorer farmers are beginning to benefit from the ongoing changes in global agriculture. The scope for wider, though location-specific, adaptation and uptake is considerable; especially as and when broader sectoral constraints can be eased (see other chapters). The participation and contributions of farmers, along with a multidisciplinary outlook, remain essential. The following paragraphs cite some current examples of ongoing developments.

Improved Management of Soil and Water Resources

24. For under-exploited resources there is scope for synergy between various knowledge-intensive improvements in management and use, which in combination can reduce risks, production or post-harvest costs, and lead to a benign spiral of sustainable, rising productivity. A common entry point in areas with uncertain rains is improved *in situ* capture of rainfall. Resultant increases in soil moisture allow more biomass production. Augmented storage of this 'green-water' reduces the risk to crops from short periods of drought during the growing season. Organic residues from increased biomass (both roots and other crop residues) will improve soil physical and chemical properties, themselves contributing to improved fertility as well as increasing the response to even small quantities of inorganic fertiliser. Above-ground biomass residues can be used in various ways depending on local circumstances – as fodder for livestock (thereby generating manure to be used to fertilise the land); and as a surface mulch to reduce soil capping and thereby facilitate infiltration of rainfall. Green manures (especially when leguminous plants are used) add further to soil organic matter and hence fertility, since all the biomass is utilised. Combinations of all these alternatives are also possible, with choices dependent on the location and family preferences and to be arrived at through stakeholder consultation and farmers' experiments. Taking account of public benefits from improved hydrological regimes, reduced erosion and less siltation of water bodies, combined with greater environmental sustainability, investments can justifiably include public grant funding to initiate change. Recent experience in Brazil and elsewhere with zero tillage is showing such benefits. The breaking up of subsoil by 'ripping' and the used of minimum tillage equipment designed specifically for small farmers is similarly showing great potential. The current spread of improved land management practices in the Indo-Gangetic Plain as a response to stagnation of production post-Green Revolution is spectacular, and exploits some of the same principles.

Box 3
Changing the System; Starting the Upward spiral
Farmer Experiences in Changing the Management of Resources

Mr. Bruma Giakete is a settled Fulani farmer in Mali. Through a participatory exercise initially supported by an IFAD grant he decided to switch some of his grain sorghum area to a sweet sorghum variety yielding less grain but more fodder, and use the extra green biomass to stall feed the best of his dairy cows. After three years he has ten cows corralled, producing a total of 25 litres of milk daily – an acceptable yield by local standards: part of the milk is sold in a nearby village and has increased the cash income of the family; part is consumed by the family and improves their nutrition. But Mr. Gikete also collected 8 tonnes of cattle manure from his dairy operation last season, which when returned to his crop land reduced the need to buy fertiliser for his grain sorghum. He has convinced four of his neighbours to try the same technology, selling them the sweet sorghum seeds needed to initiate this rising spiral of livelihood improvement and land productivity. (Source: IFAD visit report, Ahmed Sidahmed)

Agronomists in Costa Rica had been working for some years trying to raise the productivity of the traditional low-cost, mulched, *Phaseolus* bean system, applying phosphorus fertilizer before mulching. On the highly acid soils of the area virtually all the phosphorus applied was tied up immediately and farmers' bean yields averaged only around 0.5 t/ha. Martha Rosemeyer, a Cornell University doctoral candidate, and a group of farmers then tried broadcasting phosphorus fertilizer on top of the mulch – mimicking, in fact, the system by which plant nutrients are naturally recycled through the canopy of the indigenous forests of the region. The results, since confirmed in numerous additional experiments, were astounding: bean yields rose to between 1.5 and 2.5 t/ha. (Source: Minifarms@aol.com)

Integrated Pest Management

25. Integrated pest management (IPM) reduces reliance on solely chemical control to contain biotic risks to crops, to the extent possible substituting farmers' knowledge of means to encourage the enemies of pests, or to manage crops and surrounding areas in ways that place pests, diseases and weeds at a disadvantage. As in the case of rainfall capture and soil improvement, technical solutions are likely to be location-specific. They will depend on farmers' understanding of the underlying principles and close observation of what is happening in and around their own fields. Farmer Field Schools were developed to pioneer IPM and such examples of group-learning are now proving their worth as a means of disseminating other agricultural practices. Specific investment support for IPM is likely to focus on creating means for co-operation between farmers over a sufficiently wide area for integrated programmes to have an impact, helping to introduce and/or multiply enemies, training farmers to identify critical levels of both pests and predators (scouting/monitoring) and communicating the basic principles underlying pest, disease or weed management to their farming colleagues.

Participatory breeding and selection

26. Publicly funded plant breeding programmes were among the major casualties from the cuts to government budgets under the SAPs of the 1980s. Plant collections and breeding stocks were lost and national capacities for varietal adaptation eroded. Partly as a consequence, the recent products of centralised crop improvement projects have often not been widely adopted by poor farmers: released varieties do not necessarily match the needs of the poor by combining versatility, multiple end-use and stress tolerance in diverse locations. Indeed to spread risks, poor farmers tend to grow a number of different varieties of the same crop, each with differing characteristics and tolerances. In the case of livestock, more rustic breeds are often preferred. Increasingly, the products of modern science and technology, blended with plant and animal varieties of possibly lower potential (but better adapted), are being used by farmers. While scientists may carry out the original cross-breeding, farmers themselves can be assisted to select promising lines from local landraces, and to evaluate them against so-called improved varieties at an earlier stage than under traditional R&D approaches. This approach can result in the earlier adoption of improved varieties/breeds, often with a wider range reaching commercialisation to take account of locational differences and risk reduction, and with consequent livelihood gains. Biodiversity manifested by landraces and indigenous breeds of livestock are also retained in production systems, improving potential resilience in the face of future shocks and stresses such as are posed by climatic change or the arrival of new pests or diseases.

(b) Some future needs

27. In the case of the examples given below progress is often incipient. Further support for science and technology programmes will be needed before more rural people will become able to exploit these examples to improve their livelihoods. Examples include research and development on topics such as the 'orphan' animal diseases and crops of the rural poor, reduction of post harvest losses and increased value added on-farm, quality enhancement during production and processing , meeting supermarket and government demands on the quality, origin and labelling of produce, biotechnology in its various guises, labour saving or seasonal spreading of labour demands for production of staple foods by families affected by HIV/AIDS, and nutritional enhancement of the staple foods of the poor. Wider exploitation of such potentials will be particularly important in facing the major challenge of providing a way forward for families currently trapped in Rural World 3 – opening ways for them towards improved food security, more secure part-time or subsistence farming, product diversification, greater opportunities for local off-farm employment, or escape from agriculture altogether, according to local potentials and individual preferences.

Widening Crop/Livestock Integration

28. Temperate farmers have used ley-farming systems and cereal/legume rotations to great advantage in support of crop and livestock enterprises on mixed farms for centuries, but crop/livestock integration has not made great inroads into tropical regions with the notable exception of Asia. Whilst the independent benefits to the farmer of crop and livestock production are well recognised, there is a lack of research to improve and boost

adoption of integrated crop/livestock systems for the tropics. These are important not only because of direct contributions to farm incomes but because of their generation of public environmental goods via soil improvement and greater sustainability of farming systems. The current increases in the proportion of livestock products in diets in developing countries will also raise the economic importance of feed demands, pushing more small farmers towards growing crops specifically as livestock feed in an integrated crop/livestock enterprise, instead of seeing their livestock as merely scavengers or consumers of crop residues (see Box 3). It is worthy of note that the CGIAR supports mainly crop-related compared with livestock related research and crop/livestock integration is currently well down the list of research priorities. This topic should be included as a worthwhile focus for expanded S&T programmes, along with rangeland and pasture management.

Value Addition through Diversification

29. Diversification into higher value products, integration and linkage into market chains, and enhanced value added through on-farm processing and storage are often cited as routes to poverty alleviation. Irrigation infrastructure, often constructed in the past using public funds and with inadequate concern for profitability of the staple crops it was originally intended to produce, has in many countries since become a pole of new agricultural employment for the very poor (RW 3 and 4) as better markets and communications have drawn entrepreneurs with access to capital (RWs 1 and 2) to produce, process and in some cases export fruit, vegetables and the like. Such developments can serve as entry points for alleviation of rural poverty via job creation and multiplier effects in the local economy. Smaller farmers have also themselves entered niche markets for fresh fruit and vegetables for supermarkets, animal and forest products, herbs, medicinal plants or organically-grown foods; science and technology can have an important role in opening up such opportunities. However as noted above, there are many obstacles to entry and risks for poorer farmers. Before exposing the poorest to such risks it is essential to establish market opportunities and demonstrate the profitability of the proposed new commercial ventures. Farmer groups or associations will have a key role; and farmers themselves should retain full commercial control – in contrast to the government-managed co-operatives that have so often failed in the past. But prospects for success of diversification are greatest where scientists are also required to fully understand the economics, market requirements and commercial objectives of the technical improvements they are trying to facilitate. Investment support should bring these scientists together with those concerned with the input and marketing sides, potential producers/processors, and other stakeholders including local politicians and government administrators.

Meeting quality and regulatory standards

30. In the context of diversification products of the sorts mentioned above, it should be noted that it is not only supermarkets, consumers and regulators in developed countries who are demanding ever more rigorous produce standards. Developing countries are starting to make similar demands. Diversification programmes, in particular, need to be linked to R&D programmes aimed to help smaller farmers meet these demands for uniformity, delivery, labelling and the like – especially for certification of produce as of organic origin. While outgrower schemes overseen technically by a major

processor or exporter can help, they leave small farmers with little longer-term influence over commercial operations: empowerment to demand their own S&T programmes and give them direct influence on markets and with regulators is denied them. Investment is needed to fill this gap. Even in the case of low-value staple crops it should not be forgotten, also, that while low quality (e.g. a high percentage of broken or shrivelled grains) may not prevent sale, it will lower farm-gate price. R&D on means to help small farmers maintain quality of staples is at present greatly overshadowed by work aimed at raising yields.

Advanced technologies

31. Notably absent from the research agenda until very recently has been the application of the potential of biotechnologies, particularly genetic modification, to the needs of the rural poor. Here attention to biosafety should always be the first priority. But given that the right safety standards are in place and fully met, genetic modification holds great potential to adapt crops and some livestock to the soil, climatic and biotic stresses faced by poor and subsistence farmers, as well as for human and animal dietary improvement. Such objectives are unlikely to be financially attractive to the commercial originators of the first generation GM products which were developed to suit the requirements of intensive (RW1) farming systems – e.g. for herbicide tolerance by industrial crops. Furthermore access to pro-poor GM technology is constrained by the fact that many of the GM production protocols are privately patented. Licence to use, or avoidance of, these patents is an urgent necessity; public funds could be used to contract biotechnology companies to do research designed to generate such public goods. In parallel, public R&D investment programmes and policy dialogue should favour the uptake by RW1 producers of those advanced, and where appropriate GM-based, technologies that favour labour over capital intensification, and offer a pathway for the poor living in areas without foreseeable productive potential to leave agriculture.

Box 4
Agricultural Biotechnology and the Rural Poor

Biotechnology, in the broadest sense, has benefited farmers of most types over many years – for instance through tissue culture to 'clean up' virus infected stocks of perennial crops like cassava, yams, potatoes and fruit trees ready for re-propagation; chemical mutagenesis in plant breeding; or artificial insemination of livestock. More recent and more controversial is the application of genomics (information on the identity, location and function of individual genes), and particularly genetic modification using this information, for targeted crop and livestock improvements. However genomics have also been applied less controversially for innovative improvements in livestock (and human) disease diagnosis, more effective vaccines, and to attach molecular markers to genes desirable to plant breeders – thus reducing the hit-and-miss element of plant breeding and speeding selection.

As is well known, much of this biotechnology effort has so far has been financed by multinational companies and targets the main commercial crops of developed countries. Public fears over safety and regulatory interventions have dominated the debate and rational consideration of what the same sorts of genomic intervention could achieve if applied to the needs of the rural poor in developing countries have not caught the attention of policy makers or the general public. Yet, subject to rigorous prior attention to bio-safety, much could be gained. Poor farmers would benefit from diagnostic kits and improved vaccines for the 'orphan' diseases of their livestock and accelerated improvement of their 'orphan' crops – i.e. those not given priority by the international biotechnology companies. Crops and livestock of the rural poor could be genetically modified for better tolerance of stresses such as drought, heat, soil acidity and salinity. Nutritional characteristics of the staple crops and foods of the poor could be improved. However unlike the biotechnology and genetic modification that is widespread at present, these innovations are unlikely to be commercially attractive. They would come into the category of public goods, and to develop them would have to be the funding responsibility of the public sector. Furthermore means would have to be found to draw on biotechnology processes and products that are currently privately patented. These issues are further discussed in Box 5

Meanwhile a few more advanced developing countries (China, Brazil, India, South Africa) are now entering the field with a 'second generation' of biotechnology products of their own. Although so far aimed mostly at the same internationally important crops as those targeted by multinationals, capacity is being created in the public sector which could be directed more specifically towards the needs of the poor.

Loss reduction

32. While integrated pest management targets some of the more obvious and catastrophic sources of loss by producers, there are many other sources of loss both on-field, and post harvest or in storage which contribute to poverty. It has been estimated

that together these losses may halve the potential value of sales by small farmers, while R&D expenditures on loss reduction may be only 10% of total R&D budgets (7). There is clearly a large gap in S&T investment in loss reduction, spanning a much wider range of potentials for loss than those currently being addressed by IPM programmes.

Value addition post-harvest

33. The opportunities for small scale producers to add value to their primary output by post-harvest processing or through on-farm storage to take advantage of favourable future prices, are widely recognised and frequently written about. However S&T investments to allow the rural poor to take better advantage of such opportunities are also currently limited and need to be increased.

34. Opportunities for technology change such as those sketched above should not be seen merely as alternatives. The new R&D framework, the contributions of farmers themselves, plus the altered mindsets of scientists and extension specialists needed to make it effective, should help poor people and communities to combine technology changes in ways best adapted to their diverse local needs. The overall aim of the institutional and operational changes in column three of Table 1 is to speed this knowledge-intensive matching and mixing. Examples include a combination of labour-saving technology for subsistence crops with small areas of diversification, in response to the labour constraints of AIDS victims and female headed households; or diversification into production or processing technologies with high labour demands where poverty can be reduced through increased rural employment. While leaving the land may be inevitable for some, urban drift has been reduced where improved soil and moisture management have raised productivity, or simply restored it in the face of decline.

VII. Planning for Efficient Investment in Pro-Poor Science and Technology

35. Planning for efficient investment in science and technology for pro-poor agricultural growth is demanding; like all development planning is a time consuming and usually iterative process. S&T investment plans must be coherent with overall national plans for economic development and poverty reduction, and contribute to the attainment of MDGs. Within the conceptual framework and opportunities or future needs for technology of the sorts exemplified earlier, planners have to decide the maximum that can be attempted technically in caring for the needs of the inhabitants of different Rural Worlds as well as priorities among the different target groups within Rural Worlds. At the same time they must invest in building up the capacities of the various stakeholders who will be responsible for implementation. Planners must also take account of technical constraints and risks due to the quality of the resource base, and the extent to which target communities have access to or control over those resources. They must distinguish between situations which are amenable to poverty alleviation through technical advances and cases where the lot of the poor can be better, or must first be, improved by other means – particularly via support for health, domestic water, education or infrastructure programmes or under temporary poverty safety nets. Programmes must link farmer empowerment and participation in the local adaptation of technology with means to identify and bring in a flow of new, external scientific knowledge that will continue to

feed this local adaptation. Individuals supporting implementation and technology flows in this way need to acquire the mindsets, and be given access to the knowledge, means and incentives, to become willing partners with poor rural people in the search for routes out of poverty.

36. The details of the planning process will be as country or location specific as the outcome. While investment planning may be administered and co-ordinated under a technical ministry or a body responsible for rural development in some form, it is likely to be steered by a broader coalition in which finance, trade, national planning for poverty alleviation, social, environmental and infrastructure bodies will be represented. Representatives of the private or voluntary sectors may be co-opted. Depending on the wishes of the government, external lenders or donors may assist. A logical framework may be a useful aid to debate and decision making on programme design, and in the selection of indicators for progress monitoring and impact evaluation. Typically, the planning process will include the following steps.

- *Explore the need for and relevance of investment in science and technology to the alleviation of rural poverty*. This crucial first step will require an overview of national development policies, Poverty Reduction Strategies, agricultural priorities and their connections with poverty reduction plans; current government allocations to poverty relief or alleviation; funding gaps; identified target groups; technology demands and potentials; already ongoing or planned external assistance with pro-poor S&T; key features of the resource base; and the perceived technical constraints and opportunities for priority areas or target groups.

- *Develop a science and technology strategy*. Once a general case has been made that science and technology investments could be relevant to national poverty alleviation and that there are needs for additional funding, investigation should move to the field/community level. Participatory Rural Appraisals or similar rural diagnostic techniques will normally be used to establish hierarchies of constraints in different agro-ecological zones, identify local target groups and stakeholders, screen possible locations for implementation and assess potentials for community-based action. It will be the opportunity also to evaluate alternative locations and facilities for on-station, on field and farmer-participatory R&D.

- *Confirm the Science and Technology approach*. Armed with the above findings the planners are able to make definitive decisions on the priority to be given to S&T investments as part of the national poverty reduction strategy and plans. Interdependence with other investment interventions such as health, education, finance, marketing or access roads should be clarified and links/sequencing with these investments agreed.

- *Detail the S&T investment plan.* After S&T investment is adopted as a priority and its function among other poverty-oriented interventions is agreed, detailed planning of an investment programme can begin. Questions to cover are the

technical priorities for the programme, expected results, types of investigation and dissemination to be mounted, approaches to beneficiary empowerment, implementation and support service responsibilities at levels from the rural communities upwards, assessment of the intended implementing organisations and gaps in their capacities vis-à-vis the roles assigned to them, plans for capacity building and training for different categories of stakeholder, sources and means to link local efforts with outside sources of knowledge, cost items and funding needs, contributions of and co-ordination with financing partners, and monitoring and evaluation. An implementation plan or operating manual may be written for the benefit of stakeholders, focused on programme aims, responsibilities of different participants, sources of funding, disbursement, organisation and management structures, M&E, and the risks or issues to be borne in mind by the stakeholders.

37. An essential need in a completed S&T investment plan is that it provides for knowledge and innovation to flow in two directions. A farmer-centric, participatory approach requires that the products of strategic, applied and maintenance research ("modern" science) should move from trained scientists to farmers and rural communities; and the demands and indigenous knowledge of the rural communities should flow to the scientists. Local demands should help frame the programme aims and priorities. Demand may be further illuminated by participation of the other stakeholders – e.g. private sector input suppliers, processors or buyers.

38. Both "modern" science and indigenous knowledge will feature in the menus of technical options for poverty reduction from which technology users and scientists, in partnership, decide on their experimental programmes or exercises in community learning. Table 2 summarises who, typically, is responsible for what in the research continuum from basic research at global level to the adaptation and diffusion of new technologies at field or community level. A distinction is made in the Table between those with primary implementing responsibility, and other stakeholders whose contributions generally either contribute to better definition of demands or to the easing of non-technical constraints upstream or downstream of agricultural production and processing.

Main investment categories

39. The main investment categories within a science and technology investment plan – that is the things on which lender, donor, government or stakeholder money is spent – tend to be few. Table 3 lists some typical operational, support and investment needs for the different categories of actor and stakeholder along the research and development continuum. Given the shifts from a top-down to a participatory approach to implementation of S&T programmes and in the shifting demands of global agriculture, investment plans will tend to stress – in one guise or another—the creation of new mindsets, broadening of the information base for decision making and strengthened communications. Clearly general categories like 'training' will cover much diversity depending on, for instance, whether trainees are applied scientists in a national research

service or a group of poor farmers setting up a Farmer Field School. Likewise ‘capacity creation’ tends to cover clusters of linked expenditures

40. Some typical cost categories include:

- Information and knowledge management support, ranging widely from internet connections for the use of research institutes or village terminals for contracted service providers and farmers, through telephone links to markets, the production of radio and TV programmes to disseminate new technologies, and research publications or manuals, leaflets, posters or mobile theatre shows in villages.
- Training, ranging from university courses to courses that prepare farmer groups to set up participatory technology testing and dissemination groups. Learning by doing and exchanges or visits to see new R&D approaches in action are powerful means to reform the mindsets of stakeholders with entrenched top-down views of technology dissemination. Didactic approaches, especially for poor rural people, should be minimised.
- Support or grant funds. Instead of channelling funds for technology dissemination and other support services to the budgets of government ministries and line departments, competitive grants are now often used to contract those considered the most effective choices as service providers. Contracts to support farmer learning groups or carry out adaptive research may be awarded to NGOs, the private sector or departments in the public sector. Frequently the capacity of the selected service provider itself will need to be strengthened at the same time, via training and grant funding of some equipment. Grants are also an effective means to share with poor people or communities the costs and risks of technology change, or to reward them for the public environmental or other benefits to that may accrue from the changes they make. Clear rules and procedures are essential for the operation of funds, whether to provide outright grants or for cost sharing.
- Salary incentives and vehicles. These generally fit together in encouraging and allowing members of neglected government technical services to spend the time with rural communities that the implementation framework demands. The time for which the recipients are to stay close to given rural communities needs careful thought, however. Commitments should be assessed at the planning stage as to whether they can be sustained financially – e.g. by communities eventually taking over the costs – or whether, instead, a fixed cut-off should be imposed, by when the recipients should have become independent and no longer need the service provider.
- External technical assistance. Again, this should be approached as an exercise in pump priming; external assistance is usually much more expensive than contracting local support. It should be focused on skills which are genuinely unobtainable within the country and its duration should be minimised. Governments may be reluctant to borrow to finance external technical assistance; donor grants may have to be found.
- Infrastructure and equipment. If physical capacity created under past investment programmes is to be brought back into service some repair and rehabilitation will usually be needed. Some new capital items may be justified. In either case,

funding for future operation and maintenance of infrastructure and equipment must be assured under the investment plan, to prevent a new cycle of decline. For this reason capital investments in infrastructure and equipment should be kept to an essential minimum.

41. The demands of the investment programme on the government budget after disbursement of external funds ends should be calculated as part of programme planning. The share of costs to be borne in one way or another by the beneficiaries of the programme (for instance by giving their time and labour to adaptation and dissemination of technologies) by the government, by external loans and through donor grants should be summarised in a financing plan. To ensure a sustainable impact the aim should be to transfer the maximum of ongoing operation and maintenance costs to local sources during the implementation period.

VIII. Essential next steps and issues to revitalise science and technology for pro-poor growth

42. Next steps and the issues raised by the approach advocated are grouped below under a series of headings: general; related to governance; related to implementation, related to dissemination and adoption of results, and objectives for monitoring and evaluation.

General

43. *The focus of pro-poor S&T efforts should be on situations where there are realistic potentials* – i.e. where non-technical (external) constraints are not overriding, or can or are being lifted.
Issues. Potentials may be diverse. Programme designers have to be clarify whether priority should go to opening lucrative diversification markets to a few poor people, or whether science and technology can best contribute to poverty alleviation by stabilising or raising the yields only of the staple crops that are of vital importance to the mass of subsistence farmers, including part-timers in RW 3. While intentions to overcome non-technical constraints such as insecure or limited access to land, water or markets, or to limit corruption and rent seeking, may often be expressed, there is often a long history of foot-dragging in addressing the policies, laws or other bottlenecks that cause them to persist. Hence caution is needed in predicating investment plans on assumptions that difficult or politicised non-technical constraints will quickly be overcome.

44. *Exploit multiplier effects.* Promote technology changes by the less poor in RWs 1 and 2 that favour job creation and avoid those that involve capital intensification.
Issue. These more advanced and intensive farmers are mostly already set on the same path as their equivalents in developed countries – away from dependence on a large labour force. The drift of the young and able-bodied towards cities in the developing world is a further caveat to intensive producers or processors who consider adopting labour intensive technology. Technologies that generate demands for services only

indirectly connected with production (trading, transport, office work) may sometimes be better bets. Alternatively some form of pro-poor incentives or cost-sharing with RW1 or RW2 adopters may need to be devised, using public funds

45. *Focus public sector funding on the generation of public goods technology only.* Do so via contracted service providers irrespective of whether they are from the public, private or voluntary sectors.
Issue. In poorer countries, in particular, there is little capacity among any of these candidates. Hence whichever are chosen a period of perhaps costly capacity building is necessary before the action can begin. Tradeoffs may be required between using external technical assistance for a quicker start-up vs. the risks of leaving no sustained capacity thereafter.

46. *Various aspects of biotechnology hold the promise of major gains for the rural poor* (see Box 4). Incipient efforts in some developing countries to adapt these potentials to local needs should be expanded, in association with international or regional initiatives such as NEPAD Biosciences in Africa. South:south and well as north:south co-operation is needed.
Issue. Many of the processes and products needed for biotechnology adaptation to the rural poor are patented, often by large private companies. Progress will remain partly impeded until access by international and national public sector researchers is more free. Various organisational models – licensing, profit sharing, commissioning of research by holders of IPRs, voluntary release of rights – should be pursued (see Box 5). Information centres that list unpatented biotechnology useful for developing countries (e.g. Cambia) should be encouraged by the international community.

Box 5
Options for Public-Private Sector Partnerships in Agricultural R&D

Much of the agricultural technology needed for pro-poor rural growth is in the 'public goods' category – that is to say it is freely accessible to all who want to use it. Either intellectual property rights (IPRs) to it cannot be claimed because of its nature (e.g. it is a new crop rotation or knowledge-based improvement in the management of on-farm resources) or to market it is insufficiently profitable to attract commercial interest (e.g. it is a new variety of an open pollinated crop, of which farmers can readily save/multiply their own seeds). Other categories of technology – particularly biotechnologies – are potentially beneficial for the poor (see Box 4) but only if adapted further to meet their needs. The IPRs to these technologies are privately owned, and while the products concerned are profitable in their present forms, they require further adaptation. Poor people are not a sufficiently lucrative market to make adaptation worthwhile for those who hold the IPRs.

Various forms of public-private partnerships can be financed under investment programmes to tap the intellectual property rights and/or expertise of the private sector to improve the flow of public goods technology to poor farmers. Options to consider include

- Direct payments to the private sector under research contracts
- Competitive R&D grants, which defray part of the cost to the private partner, thus making pro-poor R&D more profitable
- Profit sharing, under which the R&D capacities of both partners are used and generated income from marketing the outputs is divided
- Licensing, under which, for a fee, the holder of IPRs agrees to the patented processes or inventions being used by public sector researchers, either without restriction or for specified purposes.
- Voluntary ceding of IPRs to R&D organisations in developing countries for various reasons – humanitarian, to enhance the image of the ceding company or because the invention has no commercial application to developed agriculture.

In addition, researchers in developing countries have the option of searching international databases for potentially useful processes or products, often in the field of biotechnology, which have not been patented (e.g. the Australia based website, Cambia). And as the more advanced developing countries further expand their own biotechnology programmes in their public sectors, opportunities for south:south partnerships should become more widespread.

47. *The public sector should share some of the costs of pro-poor technology change.* Changes to less environmentally damaging, more sustainable production systems generate public goods, but in the short term their adoption may require poor farmers to sacrifice income or make capital investments they can ill afford. Governments should pay some of these costs to speed moves towards sustainability, and in recognition of their benefits to society at large.

Issue. Governments may be reluctant to accept such costs as part of science and technology programmes. A possible solution to explore would be to attach the costs to budgets for poverty relief or emergency assistance. A specific international aid window (c.f. GEF) could also be used, for instance to improve methods of rangeland conservation or adapt local landraces to present-day needs.

48. *Set R&D approaches and priorities to maximise impacts on the rural poor*.
Issue. Targeting can seldom be so clear cut. Just because a technology (e.g. one that could overcomes a limiting constraint to food security for the family or lower risks) is potentially pro-poor, the less poor cannot be excluded; indeed in the normal course of events the less poor will often pioneer changes, and in doing so show poorer farmers that risks of change are worthwhile. Incentives and cost sharing (see above) can be explored to hasten these normal processes of diffusion of innovations, and thus speed technology adoption among the poorest.

49. *Build groups and associations of poor farmers to improve access to global marketing chains and raise their share in value added.* Take advantage of Fair Trade organisations and other pro-poor marketing channels.
Issue. Small farmers will always tend to produce small lots of marketable products; quality will vary between producers. More study is needed of how to maximise the effectiveness of 'push' by producer associations or 'pull' from wholesalers, processors, trade organisations or supermarkets in raising access and quality. Although market links via smallholder outgrower schemes are another option they tend to impose top-down technology and do little to enhance empowerment or reduce commercial vulnerability of the poor.

Governance of R&D systems

50. *Empowerment of rural communities should be a central aim.* Poor communities themselves should be the starting point and central feature of efforts to bring ownership of technical change to the poor. The process should draw to the maximum on the knowledge and ideas of farmers themselves. Although various mathematical tools are available to decision makers to weigh priorities and subdivide budgets, priorities and programme designs should always ultimately reflect the constraints, opportunities and demands of the rural poor.

51. *Maximise participation of stakeholders* in setting technical priorities, key steps in experimentation and dissemination, and in decision making (see Table 2). Empowerment should also be used to strengthen the rural poor in confronting the many upstream, downstream and policy constraints that limit their technical options. Include in decision making those responsible for issues related to national and regional policies, laws, infrastructure, education and resource access (see Table 3). Aim to better understand and exploit the diverse technical options open to the poor and the stratification of technology needs, ranging from the merely poor to the poorest.

Issues.

- It remains difficult to give the rural poor adequate influence in rural decision making – especially women, young people and those disadvantaged by HIV/AIDS. Links to higher processes of government policy and decision making are often largely absent and may need to be created *de novo*.
- The cost of empowerment and farmer participatory R&D is initially higher than for top-down technology dissemination; various models and experiences point the way to reducing and transferring transaction costs to communities themselves but require further study and elaboration.

Box 6
Farmer Field Schools: Origins and Future of 'Experiential Learning'

The Farmer Field Schools (FFSs) were originally set up in Indonesia in the early1990s to improve farmers' control of rice pests and reduce their dependency on insecticides. Based on initial successes, they have since spawned a wide range of organisational and funding approaches to 'experiential learning' by poor farmers. Groups in almost all parts of the developing world are now concerned not only with insect control, but with crop and livestock selection, improvement and multiplication; diversification; finance; improving access to inputs or markets; land management and natural resource conservation, or generally improving crop or livestock performance. FFSs were originally set up as a reaction to the poor success of fixed-package approaches to pest control promoted through training and visits (T&V) extension. They performed better because they gave farmers themselves the opportunity to experiment with packages, dismantle them, and incorporate their local knowledge, observations and ideas to reach more location-specific technical strategies.

Setting up such groups was initially expensive. Experts and trainers of the trainers were themselves at the time still learning and feeling their way. Farmers accustomed to dependency, cautious over risks and unfamiliar with the concept required extensive implementation support and grants for equipment and materials. However as farmers have gained confidence and the basic concept of group learning and action has been applied ever more widely, they are themselves taking the lead in what is becoming a popular movement. In Kenya, for instance, groups have set up 'commercial plots' that can finance their operations by sale of produce. In other cases groups have been given once-only grants to begin operations, which they administer themselves. 'Graduates' of earlier schools themselves mentor the setting up of these new groups, rather than continuing to rely on external support at government expense. In East Africa a Farmers Field School network has emerged spontaneously as a promotional and lobbying organisation.

Thus what started as a technical movement is increasingly becoming a general vehicle for community empowerment of the poor and a basis for community-led development. For the future, it is even being seen by zealots as a weapon against the advance of global capitalism.

- Success of the empowerment/farmer participatory model also depends on inflows of external innovations and ideas; to maximise this flow the pressures to change the mindsets and modes of operation of conventional research and development staff must be maintained.
- Transaction costs within the researcher chain from strategic to applied to adaptive research also remain high. Investment plans should stress implementation of research itself and active participation in farmer-centric initiatives. Streamline administrative overheads and bureaucracy, decentralise and devolve as far as possible.
- More thought needs to be given to means to get non-technical messages through and to, and exert leverage on, those at high levels who have ultimate powers of decision: simply to expect good intentions and fine words to carry the day in easing external constraints is seldom adequate. Lenders could require more explicit commitments to policy reforms and removing non-technical constraints to technology change as part of sectoral lending programmes. Conditionalities could be attached to support to countries under global or regional schemes such as GFAR or the proposed MAPP.

52. *Allow space for organisational experiment with decentralisation*. The Farmer Field School approach has evolved into many variants depending on local, decentralised decisions. Experiments with allowing districts to tailor their own decentralised agricultural support services are also bearing fruit. Investment plans should encourage and provide funds for further experiments in local-level organisation of S&T services.

Box 7 - Devolution and Decentralisation of Support Services An Example

Many of the World Bank's early investments in Training and Visit (T&V) extension were made in India, starting in the mid-1970s. T&V was initially highly effective and at the heart of the country's astonishing gains in food production. By the 1990s, however, productivity had begun to plateau in many T&V areas. It became evident that locally adapted changes in the management of the resource base, rather than further input based intensification, would be needed for progress to resume. The top-down package approach of T&V was ill suited to these new needs for locally adapted, knowledge based technology. Although many districts still had residual T&V systems, their staff were often deprived of mobility, demoralised and no longer had the confidence of farmers. Links to local researchers, farmer training and the private sector were in decay. Local government no longer had confidence in the system and gave it little political support or funds.

In its National Agricultural Technology Project that became effective in 1998 the Bank piloted a system under which participating states could receive funds to set up Agricultural Technology Management Agencies, which would be free to reshape the R&D systems in selected Districts according to local requirements and wishes. By 2004, in spite of expected difficulties in adapting top-down extension mindsets to a more participatory, partnership role, results have been positive: 75,000 farmers, including 10,000 women, are participating in 28 Districts. Over 10,000 Farmer Interest Groups have been formed and are now pooling their resources in local farmer federations. Farmer-to-farmer extension techniques such as visits to local 'success stories' are progressing and 'farmer professors' are expanding the impact of the revamped extension systems.
(Source: from W. Sorrenson: Aide Memoire of NATP Implementation Completion Review Mission, December 2004)

Implementation of research and development

53. *Support regional and global S&T initiatives funded by donors and IFIs.* Various global and regional initiatives have been launched or are proposed to give greater coherence, continuity and poverty orientation to agricultural R&D in developing countries. Examples include GFAR, the African Science Initiative, MAPP and the CGIAR Institutional Learning and Change initiative (ILAC). Support should be continued.
Issue: Current commitments to avoid scatter and discontinuity in donor projects for agricultural research and development should be maintained; as these larger and longer term programmes come into operation, similar vigilance will be needed.

54. Decentralise R&D operations; provide for subsidiarity. Decentralising R&D implementation to the lowest practical level allows system-specific and location-specific programming. System and location-specific solutions emerge more easily and the individual ideas and contributions both of farmers and researchers gain maximum expression.

Issue. As a corollary, better information-sharing arrangements must, however, be put in place so that individual contributions and results of local trials are available to others, generalised conclusions can be drawn, and the lessons learned are given more than local circulation.

55. *Create mindsets among scientists that are appropriate to supporting farmer participation and partnerships.* Improve career and financial incentives and local-level facilities to encourage scientists to work with communities as equal partners.
Issue. Experience with purely financial incentives shows that often money is not the sole requirement. Isolation of scientists and their families and moves to what may be culturally different places can negate material rewards. Material incentives may have to be linked to measures such as the requirement for junior scientists to spend a spell in the field supporting farmer participatory research to qualify for promotion, or limiting such assignments to those without school-age children. The same prestige should be given to publication of findings from field-level development among the rural poor as to conventional research papers.

Dissemination and adoption of new technology

56. *Maximise the involvement of farmers and rural communities themselves in technology dissemination*, building on customary patterns of rural communication.
Contract the training and technical support of these rural knowledge networks on a competitive basis to the most competent local organisations, whether in the public, private or voluntary sectors.
Issue. It will often be necessary to incur additional costs due to requirements to train and equip contracted organisation to take up these responsibilities. Takeoff of S&T programmes may be slowed by the need for these prior activities.

57. *Boost knowledge management systems for the benefit of all participants*, including through improved rural school curricula, publicity campaigns, farmer exchange visits and exercises in learning-by-doing – for instance through financing Farmer Field Schools and similar group technical initiatives (Box 6).
Issue. Investments will be needed in improved communication systems to enhance and link these activities. Needs of farmers, rural communities, their contracted support services and scientists should all be considered. Financing plans will have to allow for investments in rural radio, TV and telephones; internet access and computers; posters and leaflets; publications and virtual (on-line) libraries, and exchange visits for various categories of stakeholder.

58. *Provide poor rural people with financial incentives or compensation for adoption of eco-friendly public goods technology.* Incentives or compensation should consider both the costs of buying or hiring new machinery or equipment, and income foregone initially due to system changes. The scale of incentives should reflect the proportion of overall gain in income or reduction in risks that is an external benefit (e.g. environmental improvements, increased sustainability of future production), as opposed to a private gain to the adopter.

Issue. Definition of the scale of cost sharing is likely to be difficult and controversial, potentially needing advanced environmental economics. Cost sharing may be opposed by national policy makers and IFIs, being perceived as a covert return to the agricultural subsidies that were extinguished in the 1980s under structural adjustment programmes. Rather than seeking to draw compensation funds from the budgets of technical line ministries it may be more acceptable to define compensation as part of national programmes for the alleviation of rural poverty and budget funds under a welfare heading.

Monitoring and evaluation

59. *Monitoring the progress* of an agricultural S&T investment programmes does not differ in principle from the monitoring of other rural investments. The aim of monitoring remains to track the physical progress of implementation of the investment plan against numerical targets or milestones derived from the nature, scale and phasing of the various activities, then to link this with accounting for expenditure against budgets. Indicators will be selected according to the nature of the programme that has been designed. Progress will be reported by the implementers themselves.

60. As regards the *evaluation of the impact* of S&T investments in pro-poor science and technology, as was said at the outset the starting point of programmes is the need to promote agriculture that is sustainable. Investment should be based on technologies that are people-friendly and that are directly adoptable by, or will create new livelihood opportunities for, the rural poor. The changes that are sought should protect the resource base in general and reduce the vulnerability of the poor to shocks – whether physical such as rainfall variation, climate or pest attacks; or changes in markets and price regimes.

61. Implicit in these general criteria are that investments should improve the livelihoods of specific categories of rural poor in ways consistent with the national PRS. For RW 2 technical changes may simply raise the profitability and income of farming or output may be stabilised. For other families, particularly in RWs 3 and 4, a change in technology may reduce the time and money needed to grow food for family subsistence, so that livelihoods can be improved by earning more as paid labourers or by taking up some non-agricultural activity. For others again, particularly in RWs 3 and 4, livelihood improvement may come through job creation resulting from the uptake of diversification and intensification technologies by farmers in RWs 1 and 2, or by investments in improved local processing or creation of new marketing opportunities. As well as creating labouring jobs, the multiplier effects of such changes may open up opportunities for the poor to escape poverty by leaving primary agriculture altogether, finding employment as artisans or in the agricultural supply or service industries.

62. Defining the criteria to be used to evaluate such diverse facets of impact should be part of the process of programme design. It requires the views of many categories of stakeholders from national policy makers to poor farmers themselves. It should be borne in mind that, in contrast to the timescale for monitoring of implementation, impacts will be slow to emerge and cannot usually be reliably evaluated until several years after a

programme starts. They may only be fully detectable after ten years or longer. Evaluation needs to look at impacts at various levels. It may span micro-economic and household income data, trends in nutrition and health, extent of mobility of the poor toward livelihood improvements of various sorts, national economic impacts and impacts on the environment and sustainability. Funds should be provided at the planning stage as part of investment plans. Evaluations should always be independent and external. Results should be suitable for use by lenders and donors to decide their strategies and priorities for further support – e.g. under IFAD's PBAS.

Key References

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10. CGIAR Annual Report, 2003.

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Table 2 Research Categories, Responsibilities and Main Stakeholders

Research Implementers are shown above the dividing lines, Stakeholders below

Basic research, Global level	Multinational and major private sector companies Premier universities and academic institutions Science foundations
Strategic and applied research, International and regional level	Major private companies CGIAR Institutes; other international research organisations Regional R&D networks (CG/IROs + NARS members) Developed country universities and their outreach programmes
Applied and maintenance research, Country level	NARS public sector organizations NARS private sector members NGOs (national and international) CG and network outreach programmes National universities +/- external partners --- National rural development planners National government finance, and policy and poverty alleviation organisations Technical line ministries (crops, livestock, irrigation, trade etc) Representatives of farming community and rural workers Representatives of women's and youth organisations Representatives of agricultural supply industry, commerce and financial services Representatives of processors and exporters Major NGOs and other voluntary/private service providers Environmental agencies/activists
Adaptive and maintenance research, Sub-national/Zonal level	NARS outstations, government zonal/provincial line agency teams National level back-up staff and SMSs for the above Representatives of farmer experiment, learning and dissemination groups Contracted NGO or private sector service providers Local private sector agricultural suppliers/processors Farmer and processor organizations/co-operatives --- Community and farmer representatives, including women and youth Local government and administration and services reps. Political representatives and authorities Local savings, microfinance organisations and banks Local agricultural suppliers, processors, traders Environmental agencies and activists
Adaptive and maintenance research, Technology diffusion at village/community level	Farmers' experiment , learning and dissemination groups NARS national and zonal R&D staff partners to the above Contracted NGO, private or public sector support for farmers' experimentation, investigation and technology dissemination --- Community leaders and village level political authorities Local government and administration Women's and youth organisations Local health, welfare and poverty relief organisations Local road, irrigation, marketing etc. organisations Commercial suppliers, processors, buyers, merchants Local savings and microfinance organisations

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Table 3: Capacity Strengthening: Indicative Operational, Support or Investment Needs

Holders of IPRs relevant to pro-poor S&T (Multinational companies, foundations, universities etc.)	Means to make patented processes and products available for pro-poor R&D (licensing, profit sharing, donation etc., see Box 5)
Strategic and applied researchers; CGIAR and other international institutes, universities and networks	Increased socio-economic input to technology programmes. More "participatory", pro-poor mindsets via field visits, training and exchange visits and contacts with farmer-centric S&T programmes. Current awareness of changing global technology demands reaching the rural poor and possibly relevant technologies to investigate. Funds to gain rights to patented potentially pro-poor processes/inventions; awareness systems for relevant non-patented potentials.
Public sector NARS researchers, national and zonal/local levels	All above, plus: Incentives and mobility to support/join participatory R&D at zonal level and in the field. Working interactions and means for transfer/management of knowledge with international pro-poor researchers and regional networks. Information access and communication systems necessary for the above to be effective. Events and venues to speed transfer of innovations into participatory programmes, and communicate demands from the field to strategic/applied levels. Any necessary rehabilitation of facilities and equipment.
Private sector NARS researchers, NGOs, national universities, CGIAR/network outreachers	Above, plus: Closer communication and interactions to integrate national public sector programmes and their own pro-poor S&T programmes and farmer support services.
Technical line ministries; National finance, welfare policy and planning decision makers	Conferences, workshops, training courses, field and exchange visits, face-to-face contacts etc., to: Better understand causes of rural poverty, its wider economic and social implications and the potential role of S&T in alleviation programmes. Alert decision makers to needs for action on non-technical causes of rural poverty. Feed into national reforms of consumer regulations and laws on resource access. Better align S&T programmes with national poverty alleviation policies, strategies and programmes. Make the case for farmer participation in field level R&D and explore cost containment.
Private sector input/seed suppliers, processors, buyers, exporters, retail chains,	Participate in conferences, PRA etc., to: understand poor people's needs; be informed of programme targets and emerging results; inform other stakeholders on their commercial needs; advise how

chambers of commerce etc.	to ensure commercial relevance of pro-poor S&T programmes.
Communities, farmer associations, poor farmers, landless, women's and youth groups	Empowerment to: improve connections to and influence on markets and microfinance; strengthen their voice in dealing with local administration, services and elite groups; include indigenous knowledge and own demands in R&D programmes; build self confidence. Familiarisation with participatory R&D principles by training, exchanges, and learning through setting up own groups. Funding for initial adaptive/learning/dissemination exercises. Familiarisation with underlying technical principles of the above activities. Financial support or cost sharing to contract support services. Incentives or cost sharing for uptake of more efficient and environmentally sustainable farming practices or systems. Information access and rural communication systems.
Contracted providers of support services	Familiarisation and training in principles and modes of operation of farmer-centric participatory R&D. Ditto in relevant knowledge-intensive technologies. Basic equipment and operating funds to carry out contracted tasks. Development of human resources as appropriate to roles.
Local administration, services and political elite	Participation in, facilitation and/or support of farmer empowerment and group formation for participatory R&D. Release of line agency staff for new modes of operation. Mobilising local services and resources to ease non-technical constraints to poverty alleviation – rehabilitation of access roads, schools, wells, health posts, village markets etc.

Annex

ENABLING PRO-POOR GROWTH THROUGH AGRICULTURE
REVISED OUTLINE

Section A: The need for a New Agenda

Objective: describe what is happening in the rural economy and rural households? What is the evidence, why is there a need for a new agricultural agenda? Make the case for the new agenda I light of the current challenges, why it is not working and what needs change? What are the pathways by which agriculture contributes to pro-poor growth?

Chapter One: Overview and conceptual framework (Felicity Proctor)
Chapter Two: Rural Worlds and Household Livelihoods in pro-poor development (Tim Mahoney)

Section B: Priorities for the new agenda

Objective: Consider what is important to focus on for the PPG? Why are markets, social protection, and rural livelihoods important for PPG? What is the evident? How are the three areas linked up?

Chapter Three: Making Agricultural Markets Work Better for the Poor (David Orden, et al/ March April 2005 Meeting)
Chapter Four: Social Protection and Livelihood Promotion in Agriculture: Towards Operational Guidelines (John Farrington – March/April 2005 meetings)
Chapter Five: Increasing Diversification for Rural Livelihoods (Ellis/Neil McPherson)

Section C: Securing opportunities for the New Agenda

Chapter Six: Constraints and Opportunities for Smallholders in Global Food Chains (Bill Vorley et al - Helsinki)
Chapter seven: Recognising and tackling risk and vulnerability constraints to pro-poor agricultural growth. (John Farrington- Helsinki)
Chapter eight: Smallholders and Pro-Poor Growth (Peter Hazel , Helsinki meeting)
Chapter nine: Migrations: benefits – remittance - and harms (John Farrington/ Priya Deshingegker)

Section D: Revitalizing investment in fundamentals for pro-poor agricultural growth

Policy options would be integrated in each chapter. The chapeau would set out the importance of access to and investment in finance, water, land, etc.

Chapter 10: Re-enforcing the human capital. Reinventing education, labour, technical and organisational skills or the poorest groups (J. Grayzel)
Chapter 11: Infrastructure and PPG (Shengen Fan)
Chapter 12: Revitalising investment in science and technology for pro-poor agricultural growth (Simon Hocombe , Ahmed Sidahmed , Susan Thompson et al.)
Chapter 13: Access to natural resource base for PPG (WB/USAID)

Section E: The New Agenda: Implications for agricultural Policies

The main purpose of this Section is to underscore the urgency of moving forward with a new agricultural agenda, and to identify key actions for incorporating the new agenda into pro-poor growth strategies

Chapter 14: "Securing a Better Future for the Poor Rural Households" or "Escaping Rural Poverty"

Chapter 15: "Expanding the Parameters of the Pro-Poor Debate" or "Facilitating Adoption of the New Agenda by PRS Stakeholders".