TOWARDS USAID RE-ENGAGING IN SUPPORTING NATIONAL AGRICULTURAL RESEARCH SYSTEMS IN THE DEVELOPING WORLD

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National Agricultural Research Systems (NARS) Capacity Development Consultation

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ACRONYMS

AgGDP	Agricultural Gross Domestic Product
AKIS	Agricultural Knowledge and Information System
ASTI	Agricultural Science and Technology Indicators
BBE	Bio-Based Economy
BFS	Bureau of Food Security (USAID)
BRIC	Brazil, Russia, India and China
CGIAR	Consultative Group on International Agricultural Research
CIP	International Potato Center
EAAPP	Eastern African Agricultural Productivity Program
EPMRs	External Program Management Reviews
ERR	Economic Rate of Return
FAO	Food and Agriculture Organization
FARA	Forum for Agricultural Research in Africa
FIs	Focal Institutes
GCIARD	Global Conference on Agriculture Research for Development
GFAR	Global Forum on Agricultural Research
GMO	Genetically Modified Organism
IA	Impact Assessment
IAEG	Impact Assessment and Evaluation Group (CGIAR)
IAR4D	Integrated Agricultural Research for Development
ICW	International Centers Week (CGIAR)
IPR	Intellectual Property Rights
ISABU	Institut des Sciences Agronomiques de Burundi
ISNAR	International Service for National Agricultural Research
LAC	Latin America and the Caribbean
M&E	Monitoring and Evaluation
NARO	National Agricultural Research Organization
NARS	National Agricultural Research Systems
NGO	Non-Governmental Organization
NPM	New Public Management
OECD	Organization for Economic Co-operation and Development

OEO	Office of Economic Opportunity
PMCA	Participatory Market Chain Approach
PPP	Purchasing Power Parity
R&D	Research and Development
SPIA	Standing Panel on Impact Assessment (CGIAR)
SSA	Sub-Saharan Africa
S&T	Science and Technology
SWOT	Strengths, Weaknesses, Opportunities and Threats
TAC	Technical Advisory Committee (CGIAR)
USAID	United States Agency for International Development
WEAPP	West African Agricultural Productivity Program
WTO	World Trade Organization

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BACKGROUND

The U.S. Agency for International development (USAID) Bureau of Food Security (BFS) asked Weidemann Associates to help develop a strategy to strengthen National Agricultural Research Systems (NARS) in developing countries. As part of this process, a one-day Roundtable was held on March 5, 2013 that brought together some 30 specialists in agricultural research and agricultural research systems to discuss which USAID interventions would best strengthen NARS in developing countries. The Roundtable was preceded by a draft Issues Paper, intended to expedite the Roundtable discussion, and an accompanying literature survey (Annex 3) that highlights learning from more than five decades of NARS operations in many countries. USAID also canvassed its Missions for advice on the theme, and the revised paper reflects those 21 responses.

Invited to participate in the Roundtable were institutions/persons involved in agricultural research from governments, donors, universities, private companies, NARS, Non-Government Organizations (NGO), and multinational agricultural research institutions. Those invited were asked to do three things:

1. Review the draft issues paper and literature review and offer suggestions for improvements, corrections, and other changes;
2. Write briefly (up to three pages) what interventions by USAID will best expand and/or improve developing-country agricultural research (some did, and these have been used in finalizing the paper); and
3. Come to the Roundtable prepared to share the learning from your experiences on how best to strengthen NARS. Those unable to participate were asked to complete a questionnaire on the topic (see Annex 2 for a summary), and these were also used in the finalization.

The output from the Roundtable is this "final" issues paper (with accompanying literature review), guidance to USAID on elements to incorporate into a strategy to improve agricultural research, and a technical brief to guide USAID investments in NARS strengthening. The paper has been prepared by Han Roseboom (j.roseboom@kpnmail.nl) and Jock Anderson (jock.r.anderson@gmail.com) to whom any comments or questions may be directed. The paper identifies Issues from several perspectives: historical (chapter 1), economic and political (chapter 2), scientific (chapter 3), investment (chapter 4), organizational (chapter 5), and research approach (chapter 6), before considering the key questions regarding capacity development (chapter 7), with which some readers may prefer to begin. Conclusions from the paper and the Roundtable are presented in the concluding chapter 8.

Calls for investing in and building, strengthening and supporting NARS are by no means new (e.g., Moseman 1970, NAS 1977,[1] Arndt, Dalrymple and Ruttan 1977, Anderson 1994, Lynam and Blackie 1994 [for Africa in particular], Petit 1994) and continue (e.g., Cassman 2012, Connor and Mínguez 2012). The authors of this paper are heartened that USAID is updating its stance on this crucial aspect of agricultural development.

[1] This study of the National Academy of Sciences provides a valuable historical account of how USAID (and USDA and the Rockefeller Foundation) got into the NARS-building business in the 1960s and following decades. We have also benefited in our historical understanding from an unfinished Essay for USAID 2003 Title XII Report "Agricultural Science and Technology in International Development" by Dana G. Dalrymple.

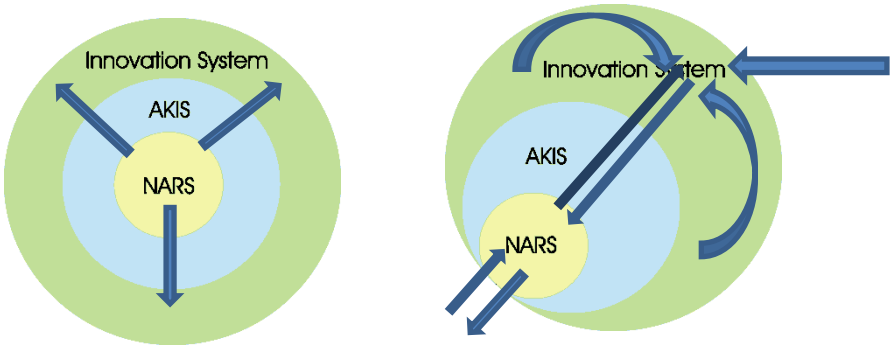
1. EVOLVING NARS PERSPECTIVE

Issue (1): *The dominant conceptual framework to look at agricultural innovation has broadened over time from the generation of (scientific) knowledge (NARS), to the generation and diffusion of knowledge (AKIS), to the generation, diffusion and application of knowledge (AIS). Thus a first issue to come to terms with is whether in 2013 it still makes sense for donors such as USAID to focus on NARS per se, or rather pursue a broader set of development concerns such as are subsumed in national AIS.*

Over the past two decades, a shift has occurred in agricultural innovation policies and strategies from a national agricultural research system (NARS) perspective (1980s), to an agricultural knowledge and information system (AKIS) perspective (1990s), and more recently to an agricultural innovation system (AIS) perspective (2000s). The latter perspective not only covers the generation and diffusion of agricultural knowledge, but also the actual application of such knowledge throughout the economy. Hence it involves a far broader set of actors than the traditional agricultural research, extension, and education agencies. This new perspective places far more emphasis on the role of markets and market actors in the innovation process. It also uses a broader set of instruments to stimulate agricultural innovation than just investment in agricultural research.

While each of the three perspectives has its own strengths and weaknesses, they can be seen as interlinked and cumulative: NARS focus on the generation of knowledge, AKIS on the generation and diffusion of knowledge, and AIS on the generation, diffusion, and application of knowledge (Figure 1).[2]

Figure 1: Linking national agricultural research systems and agricultural knowledge and information systems within an agricultural innovation systems perspective



Source: Adapted from Chema, Gilbert and Roseboom (2003).

The link between the three system concepts can be depicted as widening circles, such as in the left-hand figure. However, this would imply that research has a monopoly on knowledge generation and that without research there is no innovation. The AIS approach, however, also takes into account knowledge that is generated outside the realm of formal research through learning within the agricultural production chain—that is, learning by doing, using, and interacting. Institutional, organizational, and managerial types of innovation, in particular, often have their origin in on-site learning processes rather than off-site formal research. The two types of knowledge should be seen as complementary to each other. The

[2] In some of the literature the term agricultural knowledge and *innovation* system (AKIS) is being used as a label for AIS (e.g., EU and OECD). However, it is important to distinguish it from the earlier agricultural knowledge and *information* system (AKIS) concept. In the same vein, some authors have tried in the past to expand their definition of NARS far beyond its focus on research.

introduction of a new, research-based technology often triggers learning by users of how best to exploit it under specific circumstances. But also when it comes to scientific knowledge, the NARS does not hold a monopoly. Such knowledge (usually codified in the form of scientific articles, reports and patents) can also be acquired by the NARS from other NARS and IARCs.[3] Moreover, scientific knowledge can be embodied in agricultural inputs that can be traded internationally. They may bypass the local NARS and AKIS completely and enter local production systems directly.

World Bank (2006 and 2012) provides more detailed overview of the three concepts and summarizes their defining features in tabular form, as shown in Table 1.1. The World Bank was associated with some of the key documents that have helped to mark the transitions among these three: World Bank (1981, Elz 1984) identifying the central importance of supporting NARS development; FAO and World Bank (2000) arguing for broadening support to AKIS; and World Bank (2006a and 2012) for articulating the contemporary need to cast support still more expansively through the AIS of the developing world.

Table 1.1: Defining features of the NARS, AKIS and AIS

Defining feature	NARS	AKIS	AIS
Primary actors	Research organizations	Research, extension and education organizations	Potentially all actors in the public and private sectors involved in the creation, diffusion, adaptation, and use of agricultural knowledge
Outcome	Technology invention and technology transfer	Technology adoption and innovation in agricultural production	Different types innovation – both technological as well as institutional
Organizing principle	Using science to create new technologies	Accessing agricultural Knowledge	New uses of knowledge for social and economic change
Mechanism for innovation	Technology transfer	Knowledge and information exchange	Interaction and innovation among stakeholders
Role of policy	Resource allocation, priority Setting	Linking research, extension and education	Enabling innovation
Nature of capacity strengthening	Infrastructure and human resource development	Communication between actors in rural areas	Strengthening interactions between all actors; creating an enabling environment

Source: World Bank (2012) adapted from World Bank (2006a).

A World Bank study on agricultural innovation systems (World Bank 2006a) yielded the following findings:

1. Through its explicit attention to development outcomes, the AIS concept offers a new framework for analyzing the roles of science and technology and their interaction with other actors to generate innovations in agriculture.
2. The AIS framework can be effective in identifying the missing links in traditional sectors and potentially improving the innovation dynamics. This dynamism often depends on the presence of some sector-wide coordinating capacity for identifying innovation challenges and pursuing novel approaches to innovation.

[3] With the introduction of Internet, the better educated farmers nowadays can search for (scientific) knowledge throughout the world. Foreign study tours by farmers are another phenomenon by which farmers seek to capture the more practical knowledge specific to certain production systems.

3. Universally applicable blueprints for innovation-system development do not exist. Development practitioners must be willing to work with emerging concepts and must recognize that the interventions that they are planning will evolve while they learn.
4. The concept provides a framework for inclusive, knowledge-intensive agricultural development, but more experience is required before the contours of a truly pro-poor, pro-environment, and pro-market innovation system can be fully defined.
5. Interventions should not focus first on developing research capacity and only later on other aspects of innovation capacity. Instead, research capacity should be developed in a way that from the beginning nurtures interactions between research, private, and civil-society organizations.

Box 1.1: A definition of innovation and innovation systems

- Innovation is the process by which individuals or organizations master and implement the design and production of goods and services that are new to them, irrespective of whether they are new to their competitors, their country, or the world.
- Innovation is neither science nor technology but the generation and application of knowledge of all types (including scientific knowledge, but not limited to it) to achieve desired social and economic outcomes. Often innovation combines technical, organizational and other sorts of changes.
- An innovation system is a network of organizations, enterprises and individuals focused on bringing new products, new processes and new forms of organization into economic use, together with the institutions and policies that affect their behavior and performance.

Adapted from World Bank (2006a and 2012).

The AIS approach has been strongly influenced by the general innovation system literature, which emerged in the 1980s. In the 1990s, policymakers around the world (including middle-income developing countries) started to adopt the innovation-system concept and to launch innovation policies fairly quickly. Smits, Kuhlmann and Shapira (2010) provide a good overview of innovation-system thinking and highlight the conceptual differences between the more traditional S&T policy (based in mainstream macroeconomics) and innovation policy (based in institutional and evolutionary economics) (Table 2).

"The macroeconomic view tends to see innovation as a linear process from (basic) research via R&D to a commercial application. The main rationale [for government intervention] is market failure and the main policy instrument is science or research policy. As there is also a risk of government failure, the choices on the direction of innovation should –in this view– be left to the market as much as possible: the market organizes the allocation of resources. It leads to a fairly clear policy that can be monitored by trends in science-based indicators.

The innovation-system view has a more complicated approach to innovation and innovation policy. The focus is on interaction between different stakeholders in the innovation process. The main rationale [for government intervention] is that there are systemic (network) problems in the system or in the creation of new innovation systems. Therefore an innovation policy is needed. However, that innovation policy is much more context specific than traditional S&T policy.

While the macroeconomic view is linked to the equilibrium thinking in economics, as elaborated by well-known economists such as Ricardo, Marshall, Walras, Coase, Hayek and Friedman (to name only a few). Innovation, however, is much more about bringing the economy into disequilibrium. Several economists have contributed to that view: first of all Schumpeter with his thinking on the role of the entrepreneur, creative destruction and business cycles. He builds on work by Karl Marx (on the role of the capitalist)

and Friedrich List (the infant industry argument). Other acknowledged thinkers are Kenneth Arrow on market failure and Oliver Williamson on institutional economics." (European Commission 2012)

Table 1.2: Two Views on Innovation Policy

	Mainstream macroeconomics	Institutional and evolutionary economics
Main assumptions	Equilibrium; Perfect information	Disequilibrium; Imperfect information
Focus	Allocation of resources for invention Individuals	Interaction in innovation processes Network and frame conditions
Main rationale	Market failure	Systemic problems
Government intervenes to	- provide public goods - mitigate externalities - reduce barriers to entry - eliminate inefficient market structures	- solve problems in the system - facilitate creation of new systems - facilitate transition and avoid lock-in - induce changes in the supporting structure for innovation: create institutions and support networking
Main strengths of policies designed under this paradigm	Clarity and simplicity Analysis based on long-term trends of science-based indicators	Context specific Involvement of all policies related to innovation Holistic approach to innovation
Main weaknesses of policies designed under this paradigm	Linear model of innovation (Institutional) framework conditions are not explicitly considered	Difficult to implement Lack of indicators for analysis and evaluation of policy

Source: Smits, Kuhlmann and Shapira (2010).

The innovation system perspective helps "to understand the dynamics of innovation processes by pointing at path dependency and structural sclerosis as well as the potential for new combinations, related chances and options, and opportunities for innovation policy" (Smits, Kuhlmann and Shapira 2010, p.3).

One of the key characteristics of innovation-system thinking is that it places more emphasis on creating an enabling environment for innovation to prosper. The idea is that a strong enabling environment for (agricultural) innovation will substantially increase the chances for R&D investments to bear fruit. Module 6 of the AIS Sourcebook (World Bank 2012) gives an overview of the most crucial "enabling environment" factors and corresponding indicators that could be used to monitor them (Table 1.3).

Despite all the attention now going to agricultural innovation systems, it is still opportune to focus on the agricultural research part of the system and invest in its capacity. However, it will be impossible to do such investments without also addressing the wider environment within which agricultural innovation has to take place. Moreover, agricultural innovation system thinking has also started to influence how agricultural research is funded, organized and implemented. Increasingly, innovation policies are taking over from the more traditional S&T policies. Module 4 of the AIS Sourcebook (World Bank 2012) addresses this issue.

Perspectives on how nations best engage in agricultural research to seek growth in agricultural productivity have moved on from the widely shared views held in the development community in the era of strongest donor support for the institutional development of NARS such as in the 1970s and 80s. To ponder how the donor community might best assist developing countries address their development needs going forward means taking account of the emerging perspectives in assessing and analyzing the diverse situations facing the NARS of the developing world.

Table 1.3: Enabling Environment Factors and Indicators

Cluster	Enabling factor	Indicator(s)
Macroeconomic policies	Political / socio-economic stability	# Political instability index (the Economist) or consult the www.countryrisk.com for various stability indices
	Favorable macro-economic policies	# Net taxation of agriculture # Difference between the official and the market exchange rate # Impact of trade agreements on the agricultural sector
	Increased public investment in agriculture	# Agricultural expenditure as a percentage of total government expenditure # Share of public goods in agricultural expenditure
Education	General education	# Literacy rate (urban/rural) # Enrollment primary education (urban/rural) # Enrollment secondary education (urban/rural) # Enrollment higher education (urban/rural) # Programme for International Student Assessment (PISA) scores
	Agricultural education	# Enrollment at agricultural schools at secondary school level # Enrollment in on-the-job agricultural training schemes (e.g., farmer schools, extension courses)
	Agricultural higher education	# Number of agricultural graduates
Innovation policy and governance	A comprehensive national innovation policy in place	# Presence of a national innovation policy # Presence and use of innovation policy instruments
	Innovation governance structure in place	# Existence of a national governing body for STI # Existence of sector, industry or value chain specific governing bodies for STI # Existence of local governance structures (e.g., agricultural innovation platforms) # Interaction both vertically and horizontally between the different governance structures
	General "innovativeness" of a country	# Composite innovation indices such as the World Bank Knowledge Economy Index, the UNCTAD Innovation Capability Index or the UNDP Technology Achievement Index.
Regulatory reforms	IPR legislation and regulatory regime in place and effectively operating	# Status of IPR legislation (patents, PVR and trademarks, certification marks and geographic indications) # Capability of the IPR registration system (e.g., average time it takes to complete a registration) # Capability of the legal system to handle IPR disputes # Patent statistics (number of newly registered patents – broken down by local and foreign) # PVR statistics (number of newly registered varieties – broken down by local and foreign) # Use of certification marks and geographic indications
	Biosafety legislation and regulatory regime in place and effectively operating	# Biosafety legislation in place # Biosafety regulatory system in operation # GMO research trials allowed # Introduction of GM crops
	Agricultural health and food safety legislation and regulatory regime in place and effectively operating	# Agricultural health and food safety legislation in line with international standards # Agricultural health and food safety enforcement capability in place
	Product standards legislation and regulatory regime in place and	# Product standard legislation in line with international standards # Product standards enforcement capability in place

Cluster	Enabling factor	Indicator(s)
	effectively operating	
	Environmental regulatory regime in place that contributes to the long-term sustainability of agricultural production.	# Environmental legislation in line with international standards # Environmental impact of agricultural practices documented # More sustainable agricultural practices developed and promoted # Presence of specific measures to eliminate bad practices
Accompanying Rural investments	Well-functioning rural financial system	# Domestic credit provided by banking sector as percentage of GDP # Agricultural credit as a percentage of total domestic credit # Presence and use of agricultural insurance
	Good rural infrastructure	# Road density per square kilometer # Percentage of agricultural land under irrigation
	Well-functioning agricultural markets	# Percentage of agricultural production sold in the market # Share export in total agricultural production # Presence and strength of supply chain organizations

Source: World Bank (2012)

2. ECONOMIC AND POLITICAL STRUCTURAL CHANGES AFFECTING NARS

Issue (2a): NARS are shaped by the socio-economic and political context within which they operate. The stronger forward and backward linkages of primary agriculture as economies develop result in new innovation patterns, which require a continuous reconfiguration of NARS -- including adjustments in the public and private roles within those NARS.

Issue (2b): The expected transition to a bio-based economy will most likely have a profound impact on agricultural production worldwide. While until recently, projected demand for agricultural products was based on projected population growth plus an increase-in-income effect (more meat, vegetables and fruit). With the new demand for biomass coming from energy and industry kicking in, we are entering a far less predictable future. This will place many new demands on NARS in the coming years.

Issue (2c): The shift from a linear, top-down and highly centralized research approach towards a more interactive, participative and decentralized innovation approach requires that farmers (and other actors along agricultural value chains) organize themselves and assume active roles in agricultural innovation processes. Stimulating the development of such collective-action groups in the agricultural sector is an essential ingredient towards a more innovative agricultural sector. Ideally, such groups open the way towards more democratization and they will flourish better in open democratic societies rather than under closed repressive regimes. However, collective-action groups not only can contribute to innovation, they can also use their bargaining power to block it.

2.1 The transformation of the agro-food value chain and its impact on innovation patterns

With the shift from "producing mainly for own consumption" to "producing mainly for the market", the economic structure of the agricultural sector changes dramatically. This is best illustrated through the input-output matrices of the economy. At early stages of economic development, the forward and backward linkages of primary agriculture are relatively weak but increase substantially with the progression of economic development. This has important implications for underlying innovation patterns (an expanding role for agricultural input industries and services[4]) as well as for the perception of public and private roles in agricultural innovation. Understanding this pattern of development should help in formulating a dynamic development path for the NARS (Roseboom 2003).

One case in particular is that of plant breeding. At the early stages of development this is usually considered as a core public responsibility. However, when private seed companies start to emerge and grow, they usually also start their own plant breeding. An important pre-condition, however, is that they can protect their efforts from free-riding in the market. Hence, the introduction of plant breeder rights is an important precondition for private investment in plant breeding. Alternatively, private seed companies may decide to invest only in the breeding of hybrid cultivars.

With the emergence of a thriving private seed industry with its own plant breeding programs, it is important that **the public part of the NARS redefines its role** – shifting its focus to more up-stream, pre-competitive plant breeding research and on "orphan" crops that are neglected by the private sector. Many

[4] During the Roundtable the observation was made that in many countries the post-harvest value addition grows far faster than the value addition in the primary production process. As a result, a declining fraction of the price the consumer pays in the supermarket ends up with the farmer.

NARS struggle with these shifts in roles – public NARS actors either retract too late (and hence compete with private initiatives) or too early (leaving farmers without their needed improved materials). A persistent problem with plant breeding is that it takes a long time to develop a new variety (8-10 years) and it is hard to predict how the seed market in a particular country might look like 10 years out.

The Future Agricultures Consortium (2012) challenges this model of promoting the development of a private seed market and points to the resilience of informal, community-based seed supply systems in many African countries. It warns against a one-model-fits-all syndrome and argues that other options of seed supply should also be considered.

At the retail end of the agri-food value chain, there has been a lot of attention in recent years regarding the concentration of market power in big supermarket chains in developed countries, but increasingly also in developing countries (e.g., Reardon and Gulati 2008). These supermarket chains play an important role in setting product standards, including production practices (e.g., by requiring GAP certification). In part such standards are regulated through government legislation (e.g., food safety and agricultural health standards), but increasingly also private standards have come on board reflecting specific consumer demands such as "environmentally sustainable", "no child labor" and "fair trade". All such standards usually find their way into farmer fields through certification and have become an important factor that steers innovation at farm level.

2.2 The emergence of a bio-based economy

The bio-based economy (BBE) is about the transition from an economy based on fossil fuels to an economy based on renewable biomass as raw material, in other words a transition from "fossil-based" to "bio-based". The bio-based economy focuses in particular on the use of biomass for non-food applications, such as valuable components, chemicals, materials, transport fuels, electricity and heat. Transforming biomass into such valuable components requires bio-refinery, which is expected to advance significantly in the coming decades due to progress in applicable biotechnology.[5]

According to the proponents of a bio-based economy, we are just at the beginning of a major transformation that will affect large parts of the economy (including agriculture, industry and energy) in the coming decades. A major concern is that the biomass needed for such a transition will compete with food production. Therefore, biomass for non-food applications should come mainly from biological waste streams or grown on land that is not suitable for food production. Algae are another alternative that do not directly compete with food production. Nevertheless, some competition will be unavoidable – the high agricultural prices in recent years are in part attributed to the expansion of biofuel production and consumption. At the same time, the bio-based economy can offer ample new opportunities for farmers and for value addition to what are now "waste" products (Asveld, van Est and Stemerding 2011).

The most well-known bio-based development currently is that of the promotion of renewable, bio-based energy. Brazil has for many years been a pioneer in this area. More recently, the EU and the USA have both adopted a policy that at least a certain percentage of fuel consumption should be bio-based by a certain date. What is less well known is that this policy has also been adopted by many developing countries (often as a way to reduce their rapidly rising fuel import bills). The expansion of this trend into the future will have a profound impact on production structures as well as on power relations. The ETC Group, for example, points to how big multinationals are preparing themselves for a bio-based economy (ETC Group 2011).

[5] The term bio-based economy or bio-economy is sometimes also used in reference to the application of biotechnology throughout the economy. In our interpretation this is just one aspect of it.

Relating the emergence of a bio-based economy to the input-output matrix of agricultural production, as discussed in section 2.1, two developments can be expected:

1. The forward linkages of agricultural production will become a lot more diverse. Other industries than food processing will come on board as important clients of agriculture. Their demand for biomass may require a far faster growth of agriculture in the coming decades than expected. This poses a major challenge to agriculture worldwide; and
2. Agriculture itself is a big user of fossil energy. The production of biomass is not sustainable in the way we do it today. One of the criticisms on the first generation of bio-fuels is that their production often uses more fossil energy than what they replace. It is imperative that alternatives are developed that will fundamentally change the backward linkages of primary agriculture. In The Netherlands, for example, greenhouses have been transformed from big energy users to net energy producers.

2.3 Democratization and decentralization

Democratization and decentralization of government activities are often mentioned as important aspects of modern agricultural innovation processes (e.g., World Bank 2012). The shift from a linear, top-down and highly centralized research approach towards a more interactive, participative and decentralized innovation approach requires that farmers and other actors along agricultural value chains organize themselves and assume a more active role in agricultural innovation processes. Stimulating the development of such collective-action groups in the agricultural sector is an essential ingredient in order to progress towards a more innovative agricultural sector. For example, most competitive funding schemes to stimulate agricultural innovation nowadays require active participation of farmer organizations and/ or value chain organizations throughout the research process –i.e., research problem identification, priority setting, implementation and validation. They are often also asked to share in the costs of these projects or provide in-kind contributions such as technology dissemination. For example, Wennink and Heemskerk (2006) describe and analyze the (growing) role of farmer organizations in agricultural research and extension in three African countries. They highlight the great diversity in experience. What many farmer organizations seem to have in common, however, are financial instability and the lack of a stable funding mechanism.

Collective action groups do not only contribute to innovation, they can also block it by banning or boycotting new production methods (e.g., hybrid seeds, GM crops), preserving technology lock-in situations, or by keeping new entrants out of the market.

Decentralization of government services (including agricultural research and extension) has been a major policy theme across developing countries over the past two decades. It is often promoted as a way to bring government services closer to the citizens and help to make them more responsive to their needs (e.g., Birner and von Braun 2009). One important case concerns getting NARS research findings and products to intended beneficiaries via extension services (e.g., Birner and Anderson 2007), especially to women farmers (e.g., Jiggins, Samanta and Olawoye 1997; World Bank and IFPRI 2010). In the case of agricultural research per se, however, this decentralization push is at odds with giving high priority to research that has strong spillover effects. This is also the basic reason for the existence of the CGIAR. The promotion of regional centers of excellence by the World Bank and development partners, for example, under the East African Agricultural Productivity Program (EAAPP) and the West African Agricultural Productivity Program (WEAPP), is another example that tries to counterbalance the decentralization push. The idea is to come to a more differentiated regional research system, whereby specialized regional centers of excellence interact with local agricultural research entities.

3. PURSUING EMERGING SCIENTIFIC OPPORTUNITIES AND MEETING OLD AND NEW CHALLENGES

Issue (3a): The four most frequently mentioned scientific disciplines creating new opportunities for agricultural technology to advance in the coming years are: genetics, informatics, robotics and nanotechnology. For NARS to stay at the forefront of technological development it will be important to capture developments in these disciplines.

Issue (3b): More emphasis on integrated system approaches in agricultural research and on systemic rather than incremental innovations in order to provide solutions for the challenges being confronted.

Issue (3c): Key challenges that NARS in developing countries have to address (in addition to overall productivity enhancement) are: (1) Food security; (2) Poverty reduction; and (3) Environmental sustainability (including how to cope with global-warming effects).

3.1 Scientific opportunities

Genetics, informatics, robotics and nanotechnology are often identified as the scientific disciplines that most likely will have a deep impact on technological advances in agriculture (and other sectors) in the coming years. [6] It is in particular the interaction between these disciplines that may lead to important advances. For example, the enormous amount of information that needs to be processed for gene mapping is only possible because of advances in informatics. Advances in precision farming are making use of both informatics (knowing exactly which plant needs more or less water or nutrients) and robotics (making it more readily possible to deliver exactly the right dose).

These (new) developments in "hard" sciences are increasingly complemented with an integrated system approach whereby the focus is on the (often significant) synergy benefits that can be realized by developing new combinations of technologies and production practices. It also helps the recognition of more radical systemic innovations (rather than incremental innovations), which are often far more difficult to achieve.

Integrating these new scientific disciplines into the agricultural curriculum of universities and into the research programs of agricultural research institutes will be a major challenge for the years to come (e.g., Eicher 1999). To date, most NARS in developing countries still have quite limited capacity when it comes to biotechnology. Capacity in the other three fields is usually even more limited.

Over the past two decades, most of the discussion regarding new technological opportunities in agriculture has focused on biotechnology. Its introduction has had to deal with various obstacles, including concerns regarding its safety and IPR issues. The former has led to the introduction of an international biosafety regulatory framework (the Cartagena Protocol), which requires that countries have biosafety regulation and enforcement in place in order to screen biotechnological experiments and the release of biotechnology products for risks. All WTO members (some 157 at the moment) have committed themselves to introduce proper IPR legislation and enforcement. The lowest income countries

[6] A high-level ISNAR conference on challenges and opportunities for agricultural research in 2000 (ISNAR 1992), only identified biotechnology and system approaches (in particular integrated pest management) as the two principal opportunities. CGIAR Science Council (2005) added informatics and nanotechnology to the list, but not yet robotics.

have been given considerable lead time to implement this requirement. Without proper IPR legislation and enforcement in place, it is difficult (if not impossible) for countries to gain legal access to commercialized biotechnology. World Bank (2006c) discusses how the introduction of IPR has affected plant breeding in developing countries.

Given the dominance of profit-driven multinationals in the development and exploitation of GMOs, there is a widespread concern that biotechnological opportunities with high public but low commercial benefits will be neglected (as identified in insightful and still cogent work by Serageldin and Persley 2000). In a recent examination of the situation in the important case of India, where there is significant public capacity for molecular breeding, as well as a well-developed private-sector seed industry, Das Gupta and Ferroni (2013) point to disappointing progress in cultivar development for many crops and agroecologies.

Nanotechnology seems to raise analogous safety concerns to those in biotechnology and hence the demand for specific regulatory governance of nanotechnology (Joseph and Morrison 2006). Another similarity with biotechnology is the dominance of the private sector in the development and exploitation of nanotechnology and hence the concern that potential applications of nanotechnology with high public, but low commercial benefits will be neglected (FAO 2010, Gruère et al. 2011).

Applications of robotics and informatics in agriculture have to date been the subject of considerably less debate than biotechnology and nanotechnology. If there is debate, it tends to focus on the potential labor-replacing nature of these technologies.

3.2 Challenges

Traditionally, the primary objective of agricultural research has been to enhance agricultural productivity (i.e., producing more or better with fewer inputs) in a sustainable way (i.e., with minimal negative externalities). In the 1990s, however, a new consensus emerged (in particular in the development community) that argues that productivity enhancement as such is not the ultimate goal, but that it should contribute to higher objectives such as food security, poverty reduction, health and environmental sustainability.[7] This new consensus qualifies the type of productivity enhancement that is needed to be pursued by NARS.

This has triggered quite a bit of research trying to document the impact pathway of agricultural research and productivity enhancement towards these higher goals (e.g., Kerr and Kolavalli 1999, Byerlee 2000, Hazell and Haddad 2001, de Janvry and Sadoulet 2002, Meinzen-Dick and Adato 2007). In particular the contribution of agricultural research towards poverty reduction is often complex and diverse, as there are not only winners but also losers (i.e., adopters versus non-adopters, such as women farmers for whom some innovations may be inappropriate) and a (substantial) part of the productivity enhancement benefits are passed on to (poor) consumers in the form of lower prices. To date, the understanding of these impact pathways is still rather limited and hence has provided only tentative guidance in selecting agricultural research projects that score better on poverty reduction.

Hazell and Haddad (2001) identified the following six key priorities for a pro-poor agricultural research agenda:

1. Increasing production of staple foods in countries where food price effects are still important and/or that have a comparative advantage in growing these crops;
2. Increasing agricultural productivity in many less-favored lands, especially heavily populated low-potential areas;

[7] This thinking is also strongly influenced by the Millennium Development Goals launched by the UN in 2000.

3. Helping smallholder farms across the board diversify into higher value products, including livestock products, especially in countries with rapidly growing domestic markets for such products and/or access to suitable export markets;
4. Increasing employment and income-earning opportunities for landless and near-landless workers in labor-surplus regions;
5. Developing more nutritious and safer foods to enhance the diets of poor people; and
6. Undertaking agricultural research in ways that are more empowering to the poor and disadvantaged.

Hazell and Haddad discuss strategies for achieving each of these goals with the least trade-off in national agricultural growth (i.e., productivity enhancement). In short, they suggest strategies to target agricultural research on poor peoples' problems in ways that are "win-win" for growth and poverty reduction.

Environmental sustainability is an increasingly critical precondition for any agricultural innovation trajectory, as specifically addressed for NARS agenda-setting by Crosson and Anderson (1993). In addition, however, climate change has emerged as a major challenge for agricultural research to deal with (Alcadi, Mathur and Rémy 2009). It requires agricultural research to address the following new challenges:

1. How to reduce the contribution of agricultural production to greenhouse gas emissions?
2. How to adapt agricultural production to climate change effects (e.g., greater weather instability)?
3. How to make the transition to a bio-based economy that uses renewable energy and resources in a sustainable way?

4. RE-ENERGIZING INVESTMENT IN AGRICULTURAL RESEARCH THAT IS IMPACT ORIENTED

Issue (4a): Investment patterns in agricultural research worldwide are changing profoundly. Over the past decade, the growth of public agricultural research expenditures has accelerated in many low- and middle-income countries, but contracted in high-income countries. However, when it comes to private agricultural research expenditures (including those by agricultural input and processing industries), high-income countries have raised such expenditures to rival or exceed their public counterparts.

Issue (4b): High dependency on donor funding seems to be positively correlated with high volatility in agricultural research expenditures. Reducing such volatility could increase effectiveness and thus help to improve the overall impact of both national and donor investments.

Issue (4c): Investment in research is not a silver-bullet solution. There are many other factors that come into play that are critical to the ultimate success of agricultural innovation. To date, these other factors are relatively poorly defined and/or documented statistically. For example, there is no Agricultural Science and Technology Indicators (ASTI) equivalent for agricultural extension expenditures, in spite of them exceeding those on research in many parts of the developing world (e.g., World Bank 2007, p. 173). Moreover, if multiple factors play a role, a composite innovation indicator would be a logical development to pursue.

Issue (4d): Conventional wisdom is that the rate of return on agricultural research investment is on average high (of the order of 40%). Hence, many have argued that there is underinvestment in agricultural research. Others, however, have argued that this evidence is biased in two important ways: (i) There is a tendency to conduct impact studies only on the successes and not on the failures; and (ii) Most rate-of-return methods tend to overestimate the contribution of research. Still, the most important warning to make regarding this evidence is that high returns on agricultural research investment in the past are no guarantee for similar returns in the future (they can be worse, but also better).

Issues (4e): Technology spillovers (i.e., technology developed in one location, but being applied in another) play a major role in explaining productivity increases. Technology spill-ins are an important source of productivity growth and in particular so in small countries. The potential for technology spillover depends on various factors such as similarity in agro-ecological conditions, production systems, markets and innovation challenges. Pardey, Alston and Piggott (2006) show that technology spillovers in agriculture from developed countries to developing countries have been quite strong in the past, but argue that this will be less so in the future as agricultural R&D in developed countries is progressively shifting away from the types of agricultural R&D that are most easily adapted and adopted by developing countries.

Issue (4f): There is considerable debate around agricultural research impact assessment (IA) methods and approaches. Notwithstanding such debate, it seems there is typically too little investment[8] in IA within NARS and insufficient professional capacity to undertake such work to provide the evidence required for accountability and to distil the insights to learn from assessed experience.

[8] Data on this aspect are scarce indeed but it seems likely that few NARS allocate anything like the 1 to 2 per cent of total agricultural research expenditures to IA as advocated as good practice in the CGIAR Standing Panel on Impact Assessment (SPIA) 2008 Guidelines.

Issue (4g): Ex ante cost-benefit analysis is hardly ever used in agricultural research priority setting. It is generally considered as too costly and time consuming. A recent survey among donors also indicates that they hardly ever use quantitative priority setting tools (GDPRD 2012). However, it is possible to introduce more economic rationality into research project selection processes without insisting on an expected rate of return (ERR) calculation, for example, by introducing a structured priority setting and project selection process and the proper use of logframes in research project proposals. Moreover, instead of having only researchers sitting on selection committees, mobilize also agricultural experts with more economic expertise. Co-financing by the private sector is another mechanism that can sometimes be used to improve the economic relevance of the selected research projects, when research is not addressing primarily public-good ambitions. Another good practice is that the research proposal should give a good overview of the state-of-the-art of the research in that specific field and answer the question whether or not a solution is already available elsewhere. In this way duplication of research effort can be avoided.

4.1 Investment patterns in agricultural research

In comparison to many other S&T indicators, public agricultural research investments around the world have been fairly well-documented. For more than 25 years, the CGIAR System through ISNAR and IFPRI has invested modestly (lately with additional support from the Bill and Melinda Gates Foundation) in the development and maintenance of an international database on agricultural research investments – i.e., the Agricultural Science and Technology Indicators (ASTI) initiative.

Detailed (i.e., at institute level) country-level data compilations are being conducted at regular intervals for developing countries, which are published in a series of country reports. These country reports also provide a description of the NARS and an analysis of country-specific trends and issues. In addition, these country reports provide NARS-level agricultural research expenditure and staffing data that form the basis for more aggregate regional and global analyses. In the case of developed countries, however, ASTI nowadays relies mainly on agricultural S&T statistics published by the OECD.

A key requirement for cross-country and inter-temporal comparisons is that the same statistical definitions are used consistently throughout. For that reason, ASTI standards and definitions comply with the "Frascati Manual for S&T Indicators" published by the OECD, which is the international standard for S&T indicators. In addition, before one can make cross-country and inter-temporal comparisons, the data have to be manipulated in two ways: (1) All expenditure data have to be deflated to the same period and converted to the same currency (ASTI uses the Purchasing Power Parity [PPP] Index for this); and (2) Missing observations in the dataset have to be estimated using interpolation and extrapolation techniques as well as correlation techniques. Through the latter exercise one creates what is usually known as a meta-dataset, which is only updated every 5-10 years.

The latest global meta-dataset, which was published by ASTI in October 2012 (Beintema et al. 2012), gives an update to the year 2008. Global public agricultural research expenditures reached 31.7 billion (2005 PPP $) in 2008, up from 17.4 billion in 1981 (Table 4.1). The share of high-income countries in global public agricultural research expenditures has steadily declined over time, from 63% in 1981 to 51% in 2008. At the same time middle-income countries have seen their share go up from 24% to 46%, while low-income countries have hovered around 3%.

Table 4.1: Total public agricultural research expenditures by income group, developing region and some major developing countries

Income group / region / country	Public spending on agricultural R&D				Average annual growth rate		
	1981	1990	2000	2008	1980s	1990s	2000s
	(million 2005 PPP $)				*(percentage)*		
Global (179)	17,426	21,022	26,031	31,744	2.3	1.9	2.3
High-income (44)	10,932	12,930	15,125	16,165	2.0	1.3	0.9
Middle-income (101)	5,996	7,433	10,188	14,696	2.7	3.0	4.4
Low-income (31)	487	649	740	883	3.6	0.5	2.1
Sub-Saharan Africa (45)	1,207	1,218	1,314	1,745	0.3	-0.0	2.8
Asia& Pacific (26)	1,863	2,897	4,736	7,725	4.9	4.7	5.8
Latin America & Caribbean (28)	2,328	2,464	2,819	3,297	1.5	1.2	2.1
West Asia & North Africa (13)	NA	NA	1,544	1,848	NA	NA	2.3
Eastern Europe & former USSR (21)	NA	NA	514	983	NA	NA	8.6
Brazil	927	1,218	1,314	1,745	2.4	-0.3	1.3
India	451	779	1,487	2,121	5.8	6.7	4.5
China	658	1,055	1,907	4,048	5.8	5.1	8.8

Source: ASTI

Over the past three decades, average growth in public agricultural research expenditures has steadily declined in high-income countries, accelerated in middle-income countries and fluctuated in low-income countries.

Of the developing regions, Asia & Pacific[9] stands out as the region with the highest average growth in public agricultural research expenditures for the past 30 years. This growth is mostly driven by China and India. A further breakdown of the growth rate for the 2000s reveals that growth accelerated in particular during the latter half of the 2000s.

The BRIC "developing" countries (Brazil, India and China [i.e., excluding Russia]) together represent close to one-half of all public agricultural research expenditures by developing countries and close to one-quarter of global expenditures. In particular China and India have expanded their public agricultural research expenditures faster than most other countries.

Intensity ratio

Although global public agricultural research expenditures have increased substantially in real terms over the past three decades, in relative terms (that is relative to the size of the agricultural sector, as represented by agricultural gross domestic product, AgGDP) they have on average not (see Table 4.2). However, there is quite a bit of variation around this average agricultural research intensity (agricultural research expenditures as a percentage of AgGDP). In high-income countries, the agricultural research intensity ratio is increasing rapidly (in part due to a decline in AgGDP), while in middle- and low-income countries the agricultural research intensity remains on average fairly stable at around 0.5%. Of the developing regions, Latin America and the Caribbean (driven mainly by Brazil) stands out as having on average a higher intensity ratio than the other developing regions.

[9] The ASTI data collection as of 2012 pertains to Bangladesh, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Sri Lanka and Vietnam.

Table 4.2: Public agricultural research intensity ratio

Income group / region / country	Public agricultural R&D expenditures as a percentage of AgGDP			
	1981	1990	2000	2008
	(percentage)			
Global (179)	0.87	0.87	0.97	0.93
High-income (44)	1.52	1.89	2.63	3.07
Middle-income (101)	0.50	0.46	0.52	0.55
Low-income (31)	0.55	0.57	0.51	0.44
Sub-Saharan Africa (45)	0.74	0.57	0.56	0.60
Asia& Pacific (26)	0.32	0.32	0.38	0.42
Latin America & Caribbean (28)	0.89	0.97	1.26	1.10
West Asia & North Africa (13)	NA	NA	0.65	0.68
Eastern Europe & former USSR (21)	NA	NA	0.28	0.51
Brazil	1.15	1.65	1.86	1.52
India	0.22	0.28	0.39	0.40
China	0.38	0.31	0.38	0.50

Source: ASTI; Beintema et al. (2012)

Donor dependency and volatility of funding

Anecdotes about huge swings in agricultural research funding levels in developing countries are quite common and often linked to donor projects stepping in or out. Stads (2011) explored this issue in more detail on the basis of the ASTI expenditure time series and a volatility index capturing year-to-year fluctuations. Key conclusions of his analysis are:

1. Volatility in agricultural research funding (as measured by a volatility index) is on average substantially higher in Sub-Saharan Africa (SSA) than in Latin America and the Caribbean (LAC) and Asia & Pacific (A&P);
2. In many SSA countries national agricultural research expenditures are still highly dependent on donor funding – instances of 40% or more are not exceptional. In LAC and A&P such donor dependence is considerably lower;
3. Analyzing the volatility of individual funding sources for a group of 49 African agricultural research organizations, it turned out that donor funding is substantially more volatile than government funding or own income; and
4. Concurrent with expectations, volatility per cost category is the lowest for salaries and highest for capital investments and with operating costs in between.

"Abundant empirical evidence suggests that volatility in donor funding is costly, particularly in less developed countries with weak institutions, and that measures to reduce volatility would significantly enhance the value of donor aid (Kharas 2008). The fact that donor and development bank funding for agricultural R&D shows a much higher degree of volatility than other funding sources is worrying, given that many national agricultural R&D institutes in SSA, particularly those in low-income countries, derive a significant share of their total funding from donors, development banks, and SROs [sub-regional organizations]." (Stads 2011)

4.2 Agricultural research impact assessment

Latter-day active concern for impact assessment (IA) had its roots in the 1960s concerns about the effectiveness of government programs. An example (McKinsey n.d.) is: “The US experiments with assessment in 1964: As part of the Johnson administration's "War on Poverty," the Office of Economic Opportunity (OEO) is created. A division within OEO, Research, Programming, Planning, & Evaluation (RPP&E), is asked to evaluate a "central component of systematic policy decision making, conducted by a separate analytically trained staff." RPP&E fosters the setting of standards and starts a dialogue around the importance of good assessment, but is shut down by the Nixon administration in 1969.” Progress through the 70s was checkered but many governments in Europe, North America and elsewhere adopted assessment processes to track program ambitions and progress. The key concerns that emerged from these diverse initiatives were **accountability**, to assess the achievement of purpose, and **learning**, to inform design and execution of future interventions. For agricultural research the most notable IA efforts were in the international arena, and this is first overviewed as a prelude to focusing on NARS’ needs.

The CGIAR had instituted (usually on a five-year cycle) a system of external program and management reviews (EPMRs), which among many high purposes were supposed to assess and document impact. This aspect, however, was usually not handled very well. In such reviews too few resources and too little time were usually available to permit adequate impact assessment, especially in the typical absence of self-assessed impacts. To fill this void, concerned donors commissioned an Impact Study of the CGIAR centers in the mid-80s (Anon. 1985, Anderson, Herdt and Scobie 1988). In the follow-up decade most of the CGIAR centers developed mechanisms for trying to track better the impacts of their work with NARS partners. An Impact Assessment and Evaluation Group (IAEG) commissioned by the Technical Advisory Committee (TAC) reported on these IA efforts of the Centers at International Centers Week (ICW) in 1997.[10] This was followed by a more comprehensive update of IAEG at ICW1998 (IAEG 1998).

The CGIAR continued to anguish over the IA issue through the 1990s and into the new millennium and, as TAC was transformed into the Science Council, a Standing Panel on IA was established (SPIA), and became more proactive in advancing the cause of IA within the CGIAR. The SPIA website (http://impact.cgiar.org/) has several signal pieces, including the 2008 *Guidelines* for good practice (Walker et al. 2008), and a refined methodological update (Janvry et al. 2011). The SPIA website is the best single site for distilled wisdom in this field and serves to complement the best single manual of methods of evaluation of agricultural research, *Science under Scarcity* (Alston, Norton and Pardey 1995).

The issue of IA for contemporary NARS has several aspects: Is there sufficient recognition in the NARS of the importance of attending to IA? Do the NARS have sufficient capacity to attend to the needful IA? Do the NARS adequately foster an “impact culture”? To improve the impact of its research, a NARS should document the demand for the research to be conducted. Ideally, it should identify impact pathways for all research projects and conduct impact assessment studies of selected completed research projects. It should give emphasis on assessing the economic impact of the technologies developed under its programs, both ex ante and ex post. It should also train its staff in using a logframe approach consistently as a tool to improve the impact of its research.

The due attention to IA is also of considerable concern to the donor community, which looks to good IA work to inform donor support for assisting NARS development. One detailed discussion of these concerns is available in Global Donor Platform for Rural Development (2012), and is summarized in the companion Literature Abstracts document. Strong calls are made for IA to help to justify past support, as well as, through the learning function, to guide better the future assistance to NARS.

[10] See also some critical observations on these impact studies by Jock Anderson (Anderson 1997).

Recent econometric IA work has brought renewed concerns about the adequacy of investment in agricultural research in developing countries (e.g., Alston et al. 2011, Pardey, Alston and Chan-Kang 2012, Rao, Hurley and Pardey 2012). Further, Fuglie and Rada (2012, 2013) find evidence that TFP is slowly growing in SSA and that this growth can be attributed to research investments (especially by the CGIAR) and well as policy reforms and, of course, national investment in NARS. These analysts are, however, pessimistic about the future of African agriculture, based on simulations examining how new investments in research and other policy reforms might stimulate further TFP growth. When they add all these impacts up the sum falls short of where Africa needs to be going over the next several decades. They conclude that getting Africa moving will likely require a lot more than just "more of the same".

Among the many themes addressed in IA, one that has received relatively little attention per se is the impact of capacity building in NARS (taken up explicitly in chapter 7). An exception is an excellent, largely methodological, study by Gordon and Chadwick (2007). This work is one of a significant set of IAs sponsored by a donor agency (ACIAR) that has given strong emphasis to IA since its inception. Its website includes about 100 IAs, which make it one of the best compendiums of material that is not only specific to the collaborative projects supported but also home to many methodological niceties in this still hardly-settled field.

5. RE-VISITING NARS ORGANIZATION AND MANAGEMENT

Issue (5a): The most common NARS typology is based on the organizational type of the dominant public agency in the system, i.e. ministry, autonomous institute, council or university. In order to give agricultural research agencies more autonomy and reduce bureaucracy, many NARS have moved from the ministry model to the autonomous institute model or to the council model. However, it does not seem that the performance of these latter models has turned out to be much better than the ministry model.

Issue (5b): Another relevant distinguishing factor is that of size -- large NARS can afford more upstream research than small ones. Moreover, there are probably more synergy benefits within large NARS than small ones. Sometimes at the extreme small end of NARS it is better to focus on technology acquisition only.

Issue (5c): In the late 1980s, ISNAR identified 12 critical factors (see 5.2 below) that define the performance of NARS. They are still relevant today. However, two aspects that were not included initially, but that gained importance later on are: (i) Intellectual property rights (IPR); and (ii) The changing roles of public and private actors in agricultural research and public-private partnerships.

Issue (5d): Many of the NARS reforms that have been designed and implemented over the past two decades have been strongly influenced by New Public Management (NPM) ideas and concepts. The "separation between policy making, funding and implementation", competitive funding, stronger client orientation, decentralization, performance-based budgeting, etc. are all NPM ideas and concepts. However, NPM's popularity may be waning. Are we still on the right track?

Issue (5e): The adoption of stricter agricultural health, food safety and environmental standards in recent years has resulted in an increased demand for laboratory analysis as well as adequate government intervention to contain food scares and disease outbreaks. Although strictly speaking these activities are not considered research, in many countries such testing is conducted by public research institutes. The same staff and facilities are used for both testing and research. In other countries these testing activities have been spun off to a separate agency – e.g., to an agricultural health and food safety agency. Nevertheless, in many countries (and in particular in small ones) there is a shortage of analytical laboratory capacity (both physical and human) as well as intervention capacity, which are constraining progress in increasing agricultural exports.

5.1 NARS typology and analysis

Trigo (1985) identified the following five basic operational options for the organization of agricultural research, namely:

1. A directorate, department, division, or unit within the Ministry of Agriculture or Ministry of Science and Technology (i.e., the ministry model);
2. Autonomous or semi-autonomous institute;
3. University;
4. Agricultural research council; and
5. Private sector research organizations (including commodity-board type of research agencies and corporate research departments).

This classification is still relevant today. The only omission is that of NGOs as a possible organizational option, but in practice there are very few NGOs that are actually conducting agricultural research. Most of them focus on technology transfer.

At the NARS level the different organizational models often coexist next to each other. It is usually the organizational model that is most dominant within the public part of the NARS that ends up characterizing the NARS. For example, in most countries universities are involved in agricultural research, but in very few countries (except for India and the USA) are they the dominant actor. The autonomous institute model is rather popular in Latin America (i.e., the so-called INIAs, from the Spanish acronym for national agricultural research institute), while the agricultural research council (ARC) model is popular in most Asian countries. In Africa, there is a mix of organizational models -- none of the identified models is really dominant.

The critical distinction between the Latin American INIA model and the Asian ARC model is that between a centralized and decentralized mode of operation. Trigo (1985) points to the historical fact that the Asian council model often matched a decentralized responsibility for agriculture to state or provincial level, while most INIAs in Latin America evolved from centralized national departments of agriculture.

Bureaucracy and lack of autonomy are often mentioned as constraints to the performance of agricultural research entities operating within a ministerial bureaucracy. Over time, there has been in many countries a move away from the ministerial model to the "autonomous institute" model or the "agricultural research council" model. However, the performance of these latter models has not in all instances turned out to be much better than that of the ministry model. World Bank (1998) lists the following possible factors that cause such a failure: (i) Fear of abuse of the autonomous status; (ii) Weak institutional cultures; (iii) Defective design; (iv) Flawed implementation; and (v) Internal and external resistance.

After a period of consolidation of agricultural research capacity into larger entities in the 1970s and 1980s, there seems now to be a tendency in the opposite direction in the form of greater institutional diversity within NARS.

Size is another distinctive characteristic of NARS. Some NARS are as small as fewer than 10 agricultural researchers (many Caribbean islands fall in this category), while other NARS employ 10,000 researchers or more (India and China). However, in small countries the diversity in agricultural commodities and problems is largely the same as in big countries. It is mainly the agroecological diversity that tends to increase with the size of the country.

Eyzaguirre (1996) argues that NARS in small countries should define their role differently from that of NARS in large countries. They should place more emphasis on technology acquisition and less so on research and technology generation. Moreover, larger NARS can afford more specialization – in small NARS scientists have to be more generalists and perform multiple roles simultaneously.

A third distinguishing factor between NARS is that of the stage of economic development (see chapter 3). Traditionally the differentiation is just between developed and developing countries, more recently there is more of a continuum from low income to high income countries (see for example the ASTI classification). Another useful classification is the one introduced by the World Development Report 2008 (World Bank 2007), which differentiates between agriculture-based economies, transforming economies and urbanized economies. As countries move from an agriculture-based, to a transforming and on to an urbanized economy, the share of agriculture in the overall economy declines as well as the share of rural poor in the total poor.

5.2 ISNAR's critical factors

Based on ISNAR's experience of reviewing some 40 NARS between 1981 and 1988 (which included a substantive response to ISNAR's 1st External Review that had been led by Montague Yudelman in 1985, and eventuated in the articulation of the ISNAR's first Strategic Plan, which can be revisited in the archived website, and which records the many elements addressed in the diversity of projects in this era, supported by several donors, including USAID), Dagg and Eyzaguirre (1989) drew lessons from these experiences and proposed a standard framework for future NARS reviews to be more concrete on just how strengthening was best to be accomplished. This framework proposed the following 12 critical factors to be studied in order to assess the effectiveness of the system:

Policy

1. Interactions between national development policy and national agricultural research;
2. Formulating research policy: priority setting, resource allocation, long-term planning;

Structure and organization

3. Structure and organization of research systems;
4. NARS linkages with policymakers;
5. NARS linkages with extension, clients and farmers;
6. NARS linkages to sources of world knowledge and technology;

Management

7. Program formulation and program budgeting;
8. Monitoring and evaluation;
9. Information management;
10. Development and management of human resources;
11. Development and management of physical resources; and
12. Acquisition and management of financial resources.

These critical factors seem to be as relevant today as they were 25 years ago. During its existence, ISNAR has produced a considerable number of publications that target specific critical factors, including several thematic "sourcebooks" on topics such as "research-extension linkages", "monitoring and evaluation", "financing", "information management", and "agricultural research planning".[11]

Others have proposed more specific thematic issues as critical to the performance of NARS (such as institutional autonomy, decentralization, and separation of funding from implementation), but most of those issues are captured by the proposed critical factors.

Two topics that were not explicitly covered by ISNAR's 12 critical factors, but that have received a lot of attention in recent years, are: (i) intellectual property rights (IPR); and (ii) the (changing) roles of public

[11] Kaimowitz (1990), Horton et al. (1993), Tabor, Janssen and Bruneau (1998), Vernon (2001) and Gijsbers et al. (2001).

and private actors in agricultural research. ISNAR focused mainly on the functioning of the public part of the NARS (which captures 95% of the agricultural research capacity in most developing countries). The introduction of IPR opens up a window for more private-sector research activity. However, this does not happen automatically. At the same time, the introduction of IPR also affects the business model of public agricultural research organizations. The idea is that with an IPR regime in place, public agricultural research organizations are in a stronger position to commercialize their technologies and recoup (part) of the research costs in the form of royalties. In practice, however, such income often tends be substantially lower than expected and places public agricultural research organizations in difficult dilemmas such as what is a reasonable level of royalty to ask for and whether or not to grant companies exclusiveness of IPR use (World Bank 2006c). Moreover, pursuing high royalty income may steer the research agenda away from the pursuit of needed public-good products.

Twenty years ago, most agricultural research activities in developing countries were implemented by public agencies that were funded by public resources. Slowly but steadily, however, more privately funded and implemented agricultural research activities have come on board in recent years (also because agricultural input industries and food processing industries have developed and matured). In addition, many different hybrids between these two extremes have emerged, such as private companies contracting public research agencies, public programs promoting private research with subsidies or tax deduction facilities, and public-private co-financing of agricultural research activities implemented by public agricultural research agencies. In other words, the institutional and funding arrangements of agricultural research have become a lot more complex.

Two publications that discuss these issues in more detail are Fuglie and Schimmelpfennig (2000) and Byerlee and Echeverría (2002). The first focuses on the USA experience, while the second focuses primarily on experiences in developing countries.

5.3 NARS reforms

Key NARS reforms that have taken place over the past four decades:

1. During the 1970s and 1980s, NARS reforms in developing countries mainly focused on the consolidation of agricultural research capacity into larger and more professionally managed entities. Moreover, these new entities were often granted more autonomy by separating them from their parent ministry. As a result, most developing countries nowadays have a lead NARS agency (NARO, NARI, INIA, or ARC) that represents 50% or more of the total NARS capacity. At that time, most (mainly donor financed) NARS capacity-building efforts focused on these lead agencies;
2. From the late 1980s onwards, however, concerns started to arise regarding the effectiveness of many of the NAROs. As result, more appreciation for an institutionally pluralistic NARS with multiple actors started to emerge (Byerlee and Alex 1998). The idea is that this pluralism should stimulate competition (and keep complacency in check) and allow multiple research governance and funding modalities (including private funding) to be pursued. Specific attention, for example, went to mobilizing universities to become more active and effective in agricultural research (Michelsen et al. 2003);
3. Following the adoption of the concept of an institutionally pluralistic NARS, strengthening of linkages within NARS came to the forefront as an important issue. It led to the introduction of formal or informal NARS coordination mechanisms (sometimes resulting in a consolidated, national agricultural research strategy and plan) and the promotion of more cross-institutional collaboration;

4. At the same time, stronger external linkages with agricultural extension, farmer organizations, commodity boards, etc. were promoted in order to make agricultural research more responsive to the needs of farmers and other clients. Farmer participation in research priority setting, research implementation and technology validation became the norm and farmer participation also increased in research governance and funding.
5. But progress on some fronts has been slow in some places! A particular, long-recognized (e.g., Doss 1999, World Bank, Food and Agriculture Organization, and International Fund for Agricultural Development. 2009) but too often under-attended NARS client group is that of impoverished women in the food and agriculture systems of the developing world.[12] A good analysis of gender issues in NARS is made in the IFPRI review entitled *Engendering Agricultural Research* (Meinzen-Dick et al. 2010). This paper makes a case for gender equity in agricultural R&D systems. It reviews the large literature on why it is important to pay attention to gender issues in NARS and why it is necessary to recognize women's distinct food-security roles throughout agricultural value chains. The authors examine whether women are factored into the work of research institutions, and whether research institutions effectively focus on women's needs. The conceptual framework developed demonstrates the continuing need to integrate gender into setting agricultural research priorities as well as conducting the research itself.
6. Lack of responsiveness of NAROs to client needs has been attributed in part to a high concentration of agricultural research capacity at headquarters (usually in or nearby the capital). In order to bring research closer to the farmer, a more balanced spread of agricultural research capacity geographically (i.e., **de-concentration**) has been on the agenda in many countries in recent years. Sometimes, this may also involve a decentralization of the responsibility for agricultural research to lower levels of government, such as states and provinces (e.g., Ethiopia, Pakistan and Tanzania);
7. Another major NARS reform, initiated in the 1990s, has been the introduction of competitive research funding schemes replacing in part direct government grants. With their rise in importance, decision-making processes in NARS are completely redrawn. For example, in their call for research proposals, competitive funding schemes usually present a set of priority themes for which they solicit proposals. As a result, the responsibility for research priority setting becomes a shared responsibility between the funding and implementing agency. Moreover, competitive funding schemes can set all kinds of conditions that reflect preferred research practices or modalities, such as: (a) farmer participation; (b) cross-institutional collaboration; (c) interdisciplinary research; (d) inclusion of a technology transfer strategy; and (e) learning opportunities for students and young scientists.
8. The several aspects of reform overviewed above are often even individually challenging to implement, and taken together constitute quite demanding institutional and policy actions for concerned national authorities, even in countries with large sophisticated NARS. One such country, for a concrete example, is India, which is diagnosed by Das Gupta and Ferroni (2013) as continuing to fall further behind its BRIC cousins Brazil and China in managing its still-needed many reforms, such as earlier called for by several observers (e.g., Pal and Byerlee 2006).

[12] Progress has been relatively positive through CGIAR initiatives. For example, African Women in Agricultural Research and Development (AWARD, http://awardfellowships.org) is a project of the Gender and Diversity Program of the Consultative Group on International Agricultural Research (CGIAR). It seeks to strengthen the research and leadership skills of African women in agricultural science, empowering them to contribute more effectively to poverty alleviation and food security in sub-Saharan Africa (Maguire 2012).

5.4 New public management

Many of the NARS reforms implemented over the past 25 years have been influenced quite strongly by "new public management" ideas and concepts. Although the enthusiasm for NPM has waned considerably in recent years, it is still strongly present in what are now generally accepted approaches such as "autonomy of agricultural research agencies", "competitive funding", "performance contracts", and "decentralization".

In particular the introduction of competitive funding in agricultural research has been studied extensively by various agencies and authors. One of the earlier studies by Gill and Carney (1999) came to the following policy conclusions:

1. Where there is sufficient agricultural research capacity in-country to constitute an effective market, a competitive fund can stimulate competition and enhance efficiency. Where there is not, it is better for donors to concentrate on building up this capacity through institutional development across all sectors, not just in the public sector as in the past.
2. Among smaller countries where this is impracticable an alternative worth investigating is a regional fund.
3. Funds work best where government leads the institutional reform initiative, has a clear vision of priorities and is willing to put the necessary mechanisms and modalities in place.
4. The best "home" for a competitive fund is in an independent institution that does not bid for projects. Locating a fund within a traditional public-sector agricultural research institute minimizes success prospects.
5. Competitive funds are more expensive to administer than block grants, and the smaller the fund the higher the proportion of costs needed for quality administration. In the interests of setting up a pluralistic national system, funds should pay the overheads and staff costs of those from outside the public sector.
6. Monitoring and evaluation should focus on impact on intended beneficiaries. There is as much to be learned from studying failure as from studying success.
7. When setting up a fund, every effort should be made to draw on the 30 years of experience of developing this model in Latin America, including the adaptation of modalities, mechanisms, guidelines and pro formas.

A more recent study by the Word Bank (2006b) on competitive funding schemes in agricultural research and extension in Latin America and the Caribbean (LAC) revealed that in the four LAC countries studied: (a) A substantial and increasing part of the funding for agricultural research and extension is channeled through competitive funding schemes; and (b) Particularly in the bigger LAC countries, generic STI competitive funding schemes are often as important as agriculture-specific ones as a source of funding for agricultural innovation activities.

There are some important implications of these findings given the growing popularity of competitive funding schemes in agricultural innovation, namely: (a) Increased complexity of agricultural innovation funding – multiple sources of funding with different objectives and priorities; and (b) Priority setting in agricultural innovation is no longer the exclusive domain of the implementing agencies, but is increasingly shared with funding agencies.

With more than 25 years of accumulated experience with NPM approaches and methods in many countries and in many sectors, the limitations of them start to become more apparent as well.

6. RE-CONSIDERING RESEARCH APPROACHES

Issue 6a: Research approaches can be divided into two contrasting paradigms, namely reductionism versus holism. Given the dominance of the reductionist approach in research in general, there is a tendency (often deeply engrained in how research is organized, funded and practiced) to lock out holistic approaches. If we believe that holistic research approaches are valuable, it is necessary for NARS to create a more enabling environment for such approaches.

Issue 6b: According to many, the farming systems approach in agricultural research, popular in the 1970s through to the 1990s, did not fulfill its promise. Nevertheless, it has had a lasting impact in the sense that farmer participation in agricultural research is now widely promoted (although not yet so widely practiced). One of the limitations of the farming systems approach was that it did not capture the market as part of the innovation process. The value chain approach, which became popular in the 2000s, has now taken over as the principal system perspective in agricultural research.

Issue 6c: The global agricultural research system comprises a multitude of actors at the national, regional and international level with different research agendas and responsibilities as well as with different governance and incentive structures (e.g., public versus private). In order to optimize the systemic synergy between these different actors, a shared vision as well as a clear division of roles and responsibilities is needed. Recent initiatives such as GFAR's *GCARD Roadmap* (GFAR 2012) and the CGIAR reform process are trying to transform the global agricultural research system in such a way that it will yield greater impact on poverty reduction, food security and stopping environmental degradation. Have these efforts gone far enough?

6.1 Reductionism versus holism

A permanent debate in terms of research approaches (including in agricultural research), is that of reductionism versus holism. Østreng (2007) provides an excellent overview of the two contrasting paradigms.

"In reductionism, the reference is to the classical Newtonian assumption that the dynamics of any complex system can be understood from studying *the properties of its parts*. Complex systems are therefore broken down into their components and each piece is studied individually by way of disciplinary and sub-disciplinary approaches. The challenge is to find the entry points from where to address the particulars of the system.

Once one knows the parts, the dynamics of the whole can be derived. In general, scientists have been so successful in applying this method that instead of reverting back to see how their discoveries fit in with totality, they have continued to dig deeper into their specialties, continuously narrowing the focus of their research. […]

The assumption underpinning [holism] is that the properties of the parts contribute to our understanding of the whole, but the properties can only be fully understood through the dynamics of the whole. The research focus in holism is on *the relationships between the components*, i.e., on their interconnectedness, interdependencies and interactions. In holism, *the whole is more than or different from the sum of its parts*. Consequently, breaking complex systems down into their individual components by the method of reductionism is only a first approximation of the truth, and while it may afford many useful insights, it behoves scientists to put the pieces together again by way of holism. The call is for interdisciplinarity and for bringing the multiple specialities contained in disciplines together in what can be labelled *intradisciplinarity*.

It stems from the differences in focus that there are no automatic or necessary contradictions between the two "-isms". The one focuses on the *properties of parts*, the other on the *relationship between them*. Put together, they stand out as supplementary rather than conflicting, as inclusive rather than exclusive.

This notwithstanding, interdisciplinarity has never taken firm root in the disciplinary organization of academia. The organizational scheme of universities is still based in disciplinary departments, leaving the holistic approach to university centres perceived by many to be *at* the universities not *of* them. This difference has made disciplinary work the highway to academic acclaim, whereas interdisciplinarity has been the back road to, at best, congregational praise." (Østreng, 2007)

Despite the fact that both approaches can be seen as complementary, in the real world they are often portrayed as conflicting. Reductionism is still the dominant paradigm that dominates NARS, while holism continues to struggle finding its entry into mainstream research. Vanloqueren and Baret (2009), for example, illustrate how the reductionist paradigm is ingrained in the culture of NARS and lock-out more holistic approaches. Also Collinson (2000) in his history of farming systems research points to resistance by the research establishment as one of its more important constraints.

Nevertheless, developing country NARS have started to experiment with more holistic (or systemic) research approaches, which will be discussed in the next section.

6.2 From farming systems to value chains

The 1970s through to the 1990s were the heydays of "farming systems" research. The focus of study was the farm household and the aim was to optimize the performance of that household. While a lot of lessons were learned from such studies (and in particular why innovations failed – take for example the risk avoidance strategy of poor households), in the end of the day farming systems research did not really fulfill its promise. Its popularity has waned considerably in recent years. One of the criticisms on the farming systems approach was that it failed to capture the wider context (and in particular the market context) within which a farm household operates. Hence, in the 2000s, the "value chain" research approach started to take over from the "farming systems" research approach as the principal "systems" approach. However, it inherited the strong participatory orientation of farming systems research in its later days.[13]

Lessons that can be learned from the farming systems research experience that are relevant to the "value chain" research approach include: (i) A lot of resistance within research organizations to adopt the approach. The claim that the research method is superior to the more traditional, reductionist research methods annoyed the establishment; and (ii) Inadequate training of researchers in farming systems research led to poor results (Collinson 2000).

In the case of the "value chain" research approach, the whole value chain is taken into consideration, which includes farmers, but also input suppliers, traders, transporters, processors, etc. Hence participation in the various steps in the research process (problem identification, prioritization, implementation and

[13] In the late 1980s, ISNAR conducted a major study on the organization and management of On-Farm, Client-Oriented Research (OFCOR) in some eight countries. It covered farming system research approaches, although it was not limited to it. Direct links with farmers, developed through on-farm research, ensure relevance and rapid feedback. This in contrast with the more traditional approach of controlled, on-station trials. Introducing OFCOR type of approaches places the organization and management of agricultural research organizations for some important challenges. These challenges still resonate today when agricultural research organizations adopt an innovation system approach. Merrill-Sands and Kaimowitz (1989) report on the key results of the OFCOR study. Other Netherlands-based agencies have also been active in similar demand-driven approaches (e.g., Heemskerk and Kampen 2003).

validation of the research results) is broadened to all actors along the value chain. By sharing information and experiences, better insight into the problems of value chains and their possible solutions can be achieved.

One of the initiatives that has promoted such an approach is the participatory market chain approach (PMCA) developed by the International Potato Center (CIP). This is an R&D approach for fostering pro-poor, market-led innovation in commodity chains, through active participation of private and public market chain actors. CIP's Papa Andina Initiative and partners began to develop PMCA in 2001 as a means to reduce rural poverty in the Andes by linking small farmers to new market opportunities. Since 2005, PMCA has been introduced and tested in several other countries and with other commodity chains. Extensive testing has led to the publication of a PMCA User Guide (Bernet, Thiele and Zschocke 2006).

DFID evaluated the PMCA approach through its Research into Use Programme and, while focusing on how to ensure that the PMCA benefits the largest number of poor people, drew the following conclusions:

1. Market innovations can be important drivers for technical and institutional innovations that benefit poor people.
2. The PMCA is, at heart, an exercise in collective action with good potential to generate tangible direct and indirect benefits for the poor.
3. For the PMCA to benefit the poor, it is important to target market chains for commodities produced by the poor, and involve them from the outset.
4. It is also crucial to involve private-sector actors early on, to ensure an adequate "real-world" assessment of potential market chain innovations and to marshal resources for sustaining future R&D efforts.
5. To scale up application of the PMCA, NGOs and CSOs that have substantial reach in the country must play key roles in the process.
6. For the PMCA to be successfully applied, and benefit the poor, facilitation of group decision-making processes are crucial.
7. To produce significant and sustained benefits for the poor, collective action is needed at different levels, ranging from local farmer organizations to regional market-chain platforms to national associations and international fora for information and knowledge sharing. Such actions need to continue after the PMCA exercise has been completed.
8. Market chain development cannot focus exclusively on reducing poverty among producers. For market innovation to occur there must be benefits for all those along the market chain (Research into use website http://www.researchintouse.com/nrk/RIUinfo/PF/CPH01.htm).

Another initiative along similar lines is that of the Sub-Saharan Africa (SSA) Challenge Program led by the Forum for Agricultural Research in Africa (FARA) and the SROs and financed by the CGIAR. Its integrated agricultural research-for-development (IAR4D) approach is based on an (innovation) systems approach whereby all relevant stakeholders around a certain innovation challenge are brought together in an "innovation platform." Most common are commodity-specific innovation platforms, which bring together the various actors and stakeholders that make up the *value chain* for that commodity in order to identify, discuss, and resolve innovation issues. Innovation platforms on specific topics in agriculture (for example, soil erosion) are possible as well, but they are somewhat handicapped because of their substantially weaker link to the market. The principal objective of the SSA Challenge Program is to prove that the IAR4D approach is more effective than traditional research approaches. This is a very challenging research undertaking, involving 36 innovation platforms across Africa as well as 36 non-participating villages that function as counterfactuals. In other words, this is a real-life socio-economic experiment.

The final verdict is still not in, but some descriptive material has already been published (Adekunle et al. 2012).

6.3 Redefining national, regional and international roles in agricultural research

The task implicit in the title of this section is much easier said than done. One serious attempt can thus be examined in order to grapple with the "issue" flagged in Issue 6c, namely the case of the *GCARD Roadmap* prepared (Lele et al. 2010) by the Global Forum on Agricultural Research (GFAR) in 2010 for the Global Conference on Agricultural Research for Development (GCARD) and subsequently published (GFAR 2011) on the GFAR website. A follow up conference (GCARD2) took place in Uruguay in November 2012, which focused on the practical implementation of the Roadmap (Holderness 2012).

The Roadmap is drawn at a scale that does not reveal much detail that would help a would-be "re-definer" navigate the specifics at any of the national, regional or international levels. In a plea for consultative approaches to a more pluralistic approach to AR4D, the Roadmap "establishes an inclusive, rolling process of reform and capacity development…" but only the major "highways" are at all indicated. One of these is an appeal for much more attention to impact assessment (as discussed in section 4.2 above) at all levels, and effectively repeated through five of the six strategic steps recommended. Unsurprisingly, there is a strong call for "increased investments in human, institutional and financial resources for AR4D systems to meet demands in development" (see also section 4.1) but most of the advice is rather generic, including an un-nuanced call for national agricultural research intensities to reach 1% by 2025.

There are two exceptions to the generic advice on developing required institutional capacities that are worthy of mention The first (GFAR 2011, p. 25) concerns progress at the regional level: "Regional capacity development partnership is needed to: (i) generate economies of scale in collaborative AR4D, (ii) foster inter-country cooperation, learning and exchange of experiences and develop national capacities and (iii) promote more effective regional and sub-regional collaborative research and networking to make better use of available resources and enhance capacity development in the smaller and weaker national systems." The SROs of SSA illustrate the on-going attempt to implement this important idea in the case of Africa, and the Roundtable may wish to ponder the difficulties that have been encountered and the adequacy of the thrusts.[14] The second specific suggestion (also GFAR 2011, p. 25) is on capacity development where there is a pointed suggestion for targeting countries where "the needs are greatest". Putting aside the complications of delivering assistance in some countries where the needs are truly great, there is a non-trivial assessment challenge of determining such capacity development needs. This topic is taken up further in section 7.

To close this brief review of the Roadmap, mention should be made that the map is a work in progress. Some humility is embedded in the GFAR (2011, p. 26): "Wider perspectives themselves throw up innovative research, for example in value addition, reducing food chain losses and greater understanding of constraining factors such as land rights that may otherwise negate research impacts for the poor. For all stakeholders in poor farmer agriculture & food systems and along value chains to

[14] Roseboom (2011), for example, points to the difficulty the SROs are currently experiencing in formulating and implementing a truly transnational agricultural research agenda. Most African NARS see the sub-regional competitive funding schemes as a source of funding to finance their own national research priorities rather than transnational research priorities. Substantially sharper criteria are needed in order to separate the transnational research agenda from the national agendas.

be able to take advantage of new knowledge, we need greater understanding of the organizational requirements of collective actions and enterprises. This requires organization from local through to global levels, to better articulate collective needs and demands and engage more effectively with the shaping and implementation of research." This suggests that there may well be further wisdom to be distilled in efforts such as this Roundtable.

7. RE-THINKING NARS CAPACITY BUILDING

Issue (7a): There is a great need for capacity building at NARS level throughout the developing world in order to capture the benefits that science can offer farming communities. Such capacity building has not only to deal with the educational qualifications of staff at research organizations (i.e., human capital), but also with effective organizational and managerial processes within research organizations (i.e., organizational or social capital). Moreover, such organizational and managerial capacity building should help NARS to reorient themselves from 'doing research' to 'using research to foster innovation'.

Issue (7b): Many NAROs that were established during the 1970s and 1980s are now experiencing a retirement tsunami – they are rapidly losing their best-qualified and most-experienced staff. This group of researchers, recruited during the rapid expansion of the NARO at that time, often benefited from overseas training opportunities in the USA, Europe and elsewhere. Such opportunities have dried up considerably in more recent years.

Issue (7c): Nowadays, most NAROs recruit young researchers from local universities. Strengthening the research-orientation of these local universities (including inter-regional specialization) is an important precondition for NAROs in order to maintain and improve their stock of human capital. More attention is also needed for mentoring young staff and on-the-job training of all staff (researchers, technicians, administrative, etc.) in order to keep their knowledge and skills up-to-date.

Issue (7d): In addition to basic organizational and managerial processes (such as proper management of human, physical and financial resources, strategic planning, programming of activities, information management, monitoring and evaluation, etc.) that are inherent to all organizations, there are also several processes that are specific to agricultural research organizations such as: (i) Mobilization of political and financial support for agricultural research; (ii) Consultation of stakeholders during the various stages of the research process (i.e., identification, prioritization, implementation and valorization) and responsiveness to their needs; and (iii) Effective collaboration with a wide range of other actors such as other research organizations (both local as well as abroad), agricultural advisory services, development agencies, market organizations, etc.

Issue (7e): Capacity building is not a one-time event but requires permanent maintenance and update. For example, it is not uncommon to find NAROs with a research strategy or plan that is long overdue or that have not undergone an external evaluation for the past 20 years. Monitoring institutional change through tables of "strengths, weaknesses, opportunities and threats" (SWOT), as piloted in the Strengthening Capacity of Agricultural Research for Development (SCARDA) initiative, can be an attractive tool to help organizations to stay committed to improvement of their performance.

Issue (7f): In addition to building the capacity of the individual NARS components, some form of overall NARS coordination is needed in order to avoid duplication and create greater synergy. In many countries such coordination is missing or not functioning properly. The problem of the biggest entity in the NARS assuming this responsibility by default is that the other (often much smaller) NARS entities feel being sidelined. Moreover, in many countries the NARS landscape has become more complex as intermediary funding agencies (in particular competitive funding schemes) have come on board as a permanent feature of the NARS.

Issue (7g): Benchmarking of government activities has become quite a common tool among groups of countries (OECD, EU, NEPAD, etc.) to learn from each other what works best under certain conditions. In the case of agricultural research (and agricultural innovation more broadly), such a benchmarking

approach could help the process of agricultural research organizations learning how to perform better. Along a similar line of thinking is the idea of introducing a certification scheme for agricultural research organizations. For research laboratories this is already quite common.

Issue (7h): NARS capacity building is a function that most regional and sub-regional NARS organizations (such as FARA, APAARI for Asia and the Pacific, and ASARCEA for east and central Africa) have included in their mandate. Rather than organizing NARS capacity building on a bilateral basis, USAID could consider collaboration with the regional and sub-regional NARS organizations in order to strengthen their NARS capacity-building function.

7.1 Human capacity

The research staff is arguably the most valuable resource of a research organization. At independence, most developing countries started off with a NARS that was still largely dependent on foreign experts and with a local staff that was not trained sufficiently enough to take over research activities. Over the past 40 years, three important shifts have taken place:

1. *An almost complete replacement of foreign experts by national ones*. In as recent as 1981-85, the share of expatriate researchers in sub-Saharan African NARS (excluding South Africa) was still estimated at an average 29% (Pardey, Roseboom and Anderson 1991). ASTI stopped surveying this aspect in the 1990s as it was no longer relevant for most countries;
2. *A major upgrade of the educational profile of local researchers*. In 1981-85, the majority of the national researchers in SSA (55%) held only a BSc-degree. By 2008, 30% of the agricultural researchers held a PhD, 43% an MSc, and 27% a BSc. However, there are still several African NARS today that are predominantly staffed with BSc-level researchers (i.e., Guinea, Eritrea, Mozambique, Ethiopia, Zambia, Rwanda and Zimbabwe); and
3. *A very substantial increase in the number of agricultural researchers*. In sub-Saharan Africa, for example the number of FTE agricultural researchers increased from 3,060 in 1971 to 12,120 in 2008. However, the average growth rate in research staff dropped from 5.4% in the 1970s to a low 1.3% in the 1990s, to recover to an average 2.8% growth rate in the 2000s. Unfortunately, real expenditures grew on average far slower than research staff – which has resulted in declining budgets per researcher over time in SSA (Beintema and Stads 2011).

In order to nurture and further expand this pool of talent, the following is needed:

1. Invest in improving the quality (including diversity aspects) of local faculties of agriculture as they are the principal suppliers of young talent entering the NARS;
2. Create opportunities for MSc and PhD students in agricultural sciences to obtain international experience (including South-South exchange programs). There are also good experiences with "sandwich formula" PhD programs;
3. In many countries (particularly in West Africa, South Asia and West Asia) female participation in agricultural R&D is still weak, which suggests an underexploitation of the pool of human talent (e.g., Beintema 2006, Beintema et al. 2012). Measures are needed to eliminate practical barriers for female participation in agricultural research. Also cultural barriers need to be addressed, but these are often a lot more difficult to change. More important, perhaps, is that agricultural research organizations should give due attention to the special needs of female farmers as they tend to be underrepresented in farmer organizations and consultative processes (e.g., Maguire 2012);

4. Invest in upgrading the skills and knowledge of all staff through permanent learning (e.g., by setting aside a certain percentage of the budget for this purpose);
5. Offer researchers a salary package and a career perspective that is attractive and gender-sensitive, but naturally tied to strict performance criteria;
6. Offer researchers an organizational and managerial environment that is motivating (i.e., clear vision and strategy) and stimulating excellence (i.e., transparent monitoring and evaluation (M&E) of achievements);
7. Make sure that sufficient resources are available to implement research activities as planned (there is still a lot of spillage in the system because of improper planning);
8. Develop sound human-resource management (HRM) strategies for NAROs that are experiencing sudden shocks in staffing – e.g., retirement tsunamis or an exodus of staff because of better salaries elsewhere; and
9. Provide researchers with sufficient opportunities and funds to develop and maintain their network of contacts within the country as well as abroad.

7.2 Institutional capacity

As already mentioned in the previous section, in order for research talent to prosper it requires an organizational and managerial environment that is stimulating and supportive. Unfortunately, many NAROs are struggling with severe and often permanent organizational and managerial problems and, as a result, are underperforming (see Box 2). Solving these organizational and managerial problems is essential in order for NAROs to live up to their mandate.

Box 2: ***Common problems in public research organizations***

Common problems identified in reviews of World Bank support to agricultural research result from strong path-dependency in institutional development and slow institutional and policy change:

- Lack of consensus on a strategic vision for public sector research organizations and the evolution of the research system.
- Ineffective leadership for many research organizations, resulting in internal management problems and lack of political support and funding for research.
- Continued emphasis on building centralized national agricultural research organizations/institutes (NAROs/NARIs) at the expense of fostering a public-private system, including universities.
- Difficulties in establishing an appropriate legal and governance framework for research organizations to provide the efficiency and flexibility needed in managing financial, physical, and human resources.
- Loss of highly qualified scientific staff, and difficulties in recruiting the best and the brightest.
- Weak links between NAROs and other research providers, clients, technology transfer agencies, and development organizations.
- Weak accountability to clients and funders.

Source: World Bank (2006d), Module2, Box 2.5, p. 6 of the "printed version", modified 26 Nov 2006 by Eija Pehu and colleagues.

One of the key roles of ISNAR was to provide training in agricultural research management. It developed numerous training modules – some of which are still available on-line (ftp://ftp.cgiar.org/isnar/Training/).

These materials include findings from a 2000-02 thrust in Evaluating Capacity Development (Horton et al. 2003), which lives on in a specialized on-line open access journal (Horton 2011). In addition, FAO published a Management of Agricultural Research Training Manual (Asopa and Beye 1997), which leaned strongly on ISNAR materials and is also still available on line. Unfortunately, these materials have started to become out of date and could benefit from a solid update. With the demise of ISNAR, training opportunities in agricultural research management have become scarce. FAO does not presently have the capacity either. In the case of SSA, FARA and the SROs have stepped into this vacuum by launching their own Strengthening Capacity of Agricultural Research for Development (SCARDA) program, which is discussed in more detail in section 7.3.

In addition to organizational and managerial problems within NARS components (i.e., NAROs and other agricultural research agencies), the interconnectivity between the components is often very weak, to say the least. One of the main problems is that ownership of the NARS is not defined – no one can be held responsible for a poorly functioning NARS. It is a collective responsibility. One option is to formalize this responsibility and create a NARS coordinating unit. Some countries, for example, have set up an agricultural research council to perform this task. Often, however, these councils have expanded their mandate far beyond coordination by absorbing funding and implementation roles and have become bureaucratic and hierarchical entities in themselves. By their sheer size, they tend to block out new NARS actors. While some central coordination of the NARS is needed, it should be kept light, flexible and open.

Besides a central NARS coordination entity, there are also various other instruments that can help to facilitate interconnectivity within the NARS, such as: (i) National commodity or thematic programs (i.e., bringing all researchers from different research agencies together around a particular commodity or theme); (ii) National professional associations in agricultural sciences organizing workshops and conferences and sometimes also issuing their own professional journal; (iii) Competitive funding schemes that specifically favor cross-institutional collaboration; and (iv) Thematic workshops, seminars and conferences can help to boost interconnectivity within the NARS (Byerlee and Alex 1998).

In addition to strengthening organizational and managerial processes, there is also a need to transform agricultural research organizations into truly "learning organizations" that "are responsive to changes in their environment and innovative in their policies, management practices, and structures. Becoming a learning organization frequently requires: shifting from closed innovation strategies to more open ones; shifting from simple, hierarchical organizational designs to more complex ones that feature multidisciplinary teamwork and multi- organizational collaboration; shifting from traditional planning and implementation systems to adaptive management; expanding evaluation functions to encompass both accountability and learning; and incorporating societal concerns and priorities into performance incentives" (Horton 2012). In many agricultural research organizations even basic management processes tend to be problematic, which makes a transition towards managing more complex innovation processes a major challenge.

Horton (2012) argues that "for agricultural research organisations to shift their focus from *doing research* to *using research to foster innovation*, they are likely to need changes in the following areas: strategy formulation; accountability to end-users and beneficiaries; partnership policies; planning and evaluation systems; incentives; administration and finance; and organisational arrangements." Table 7.1 summarizes the type of investment and change that will be needed in order transform agricultural research organizations into effective partners in agricultural innovation processes. Mbabu and Hall (2012) describe and analyse the introduction of these principles in a recent NARS capacity building program in Papua New Guinea, which was funded by AusAID. They conclude that NARS capacity building "needs to be learning-based and participatory; it needs to be results-driven and explicitly link research to development; it needs to take a systems view, whereby research is planned and executed as part of wider development agenda and involves partnerships with policy and practice stakeholders; and it needs to be a conscientious

process whereby capacity building responds to the evolving context of the agricultural sector" (Mbabu and Hall 2012).

Table 7.1: Priorities for Investment to Support Organizational Change

Organizational element	Priority for investment and change
Capacity development and change management	Develop new competencies related to communication, facilitation, and mediation needed to work with diverse stakeholders in identifying and developing new opportunities for technical and institutional innovation
Strategy formulation	Shift from production of research outputs to fostering innovation processes that contribute to broad socioeconomic goals
Accountability and governance	Include representatives of diverse stakeholders, including smallholders, market agents, and consumers, in governance bodies
Partnership policies	Include representatives of diverse stakeholders, including smallholders, market agents, and consumers, in governance bodies
Planning and priority setting	Develop practical procedures for systematic planning and priority setting, which combine stakeholder inputs with analysis of costs and benefits
Monitoring and evaluation (M&E)	Develop learning-oriented M&E systems that clarify "impact pathways," monitor progress in relation to these markets, and use results to improve the design and implementation of ongoing and future work
Incentives for change	Reward teamwork and partnerships that produce practical results. Develop competitive grant schemes for innovation projects
Administration and finance	Increase flexibility in arrangements to allow adaptive management and responsiveness to emerging needs and opportunities
Organizational arrangements	Develop mechanisms or units to manage inter-organizational partnerships with multiple lines of accountability
Beyond the agricultural research organization	Develop specialized innovation brokerage units outside of the national agricultural research organization

Source: Horton (2012).

To conclude this section on a more general note, some key findings of a recent study commissioned by DFID as part of its support for SCARDA can be cited. From this systematic review of NARS capacity strengthening experience, Posthumus, Martin and Chancellor (2012, p.2) concluded that the requirements for successful capacity development include:

- A sound and detailed capacity needs assessment in which the beneficiary and its key stakeholder organisations play an active part.
- Strong commitment of senior managers and staff to support the capacity strengthening interventions, often as part of a change process which requires new ways of thinking and behaving and the adoption of new systems or structures.
- Adequate management structures and systems in place to capture the benefits and share good practice.
- M&E systems which document the capacity strengthening process, measure indicators and targets and have a strong focus on learning. The interventions and M&E systems have to be based on clear and justified impact pathways.
- Sustained appropriate support over a long enough period to institutionalize new approaches.
- Fostering collaborations and strengthening relationships with other NARS actors.

7.3 The SCARDA experience

The SCARDA program aims at improving the performance of agricultural research organizations in Africa through human and institutional capacity strengthening. Its first phase (2007-2011) was funded by DFID and implemented by FARA and the SROs in collaboration with various agencies providing technical assistance. Implementation of this first phase has been quite a challenge given the involvement of multiple partners with different administrative procedures and too many layers of responsibility. Unfortunately, however, this very much bogged down the implementation of the program. Nevertheless, the program has been rated as highly relevant by most partners.[15]

As a starting point, some 12 focal institutes (FIs) across Africa were selected to participate in the program. For the past 3-4 years, these FIs have been the focus of a series of capacity strengthening activities (including change management training courses, various short courses on specific topics, as well as enrolment in MSc-degree programs). The basis for these capacity strengthening interventions was a series of in-depth institutional analyses of the FIs at the beginning of the program. Most of these analyses included a SWOT analysis table, which provided a snapshot of the issues at stake. As an example, the SWOT table as produced by Institut des Sciences Agronomiques du Burundi (ISABU) in Burundi in 2007/8 is presented in table 7.2. It gives a flavor of the challenges a NARO in a small African country has to deal with. SWOT tables, such as this one for ISABU, provided an input into the change management training courses (organized regionally), the various topical short courses (sometimes regionally, sometimes locally) and the MSc program. Moreover, management trainees were stimulated to work on one or more constraints within their organization and bring that experience back to follow up events.

In order to trace the impact of the SCARDA program, the follow up study went back to staff and management of the focal institutes and asked them: (i) Whether the reported SWOT factors had changed on a five point scale (1=worsened; 2=slightly worsened; 3= no change; 4= slightly improved; and 5=improved); and (ii) Whether the change could be attributed to a SCARDA intervention (1=no contribution; 2=moderate contribution; and 3=substantial contribution). Annor-Frempong, Roseboom and Ojijo (2012) report and analyze the results of this evaluation for eight of the original 12 focal institutes and assess the usefulness of this M&E tool and how it could be improved.

The general lesson that can be derived from this pilot study is that monitoring institutional change using SWOT tables can be an attractive tool --it is simple and flexible and it can be used by any organization. However, like any M&E tool, it requires the discipline of collecting information up front as a baseline against which change can be measured. If implemented correctly, the methodology can help institutes to stay committed to improvement of their performance and capture the dynamics of organizational development (i.e., SWOT factors moving in and out of the table through time). Moreover, it offers donors a framework within which they can invest in improving organizations.

[15] The future of the SCARDA program is somewhat unsure. During phase II, it seems to take a more decentralized approach. ASARECA, for example, is pursuing its own SCARDA follow-up activities. ASARECA has prioritized capacity building as one of its top priorities.

Table 7.2: SWOT table ISABU, Burundi (2008)

Strengths	Weaknesses
• Good structure and organization • Current human resources (Sufficient staff) • Field and lab facilities • Good communication throughout the country (one language) • Existence of ISABU and government support • Partnership with other research institutes	• Centralization of administration and finance • Insufficient budget • Instability of personnel due to low motivation, salaries and conditions of service • Absence of training on the job • Low scientific level of researchers • Too few researchers and technicians • Lack of scientific and technical equipment • Poor communication with external organizations • Poor access to scientific and technical information –scientific publications, etc. • Poor linkages with other organizations nationally • Weak contact with and transfer of technology to intermediaries and farmers • Poor publication of scientific results outside ISABU • Knowledge of English language is limited • Short term research funding policies
Opportunities	**Threats**
•Increasing potential for funding from donors – increasing cooperation • Improve linkages nationally, regionally and internationally • Emergence of other organizations involved in research e.g. private sector • Partnerships for technology transfer • Regional integration e.g. east Africa • Stabilized security situation	•De-motivation and further loss of staff to other organizations offering better terms and conditions • Risk of diminishing budget •"Glass ceiling" for technicians who cannot progress to science grades on the job • Financial selectivity by donors – some programs are funded, but some are not • Political and economic instability • Loss of staff through promotion out of the organization, e.g. to Min of Ag. • Suspension of cooperation with donors, e.g. Belgium

8. CONCLUSIONS

The role that **agricultural R&D** can play in contributing to productivity growth in the agricultural sector and thereby **improving food security and reducing poverty** has long been understood. This is why USAID, after a phase of relative neglect, is revisiting its attention to agricultural development in general and, through this paper and Roundtable discussion, in particular to the role and effectiveness of NARS in agricultural development. The Roundtable concurred with the continuing **importance of effective agricultural research systems in the developing world,** but struggled, as did the authors of the preceding chapters, in identifying where, what and how support from the donor community should best be conceived and directed. Skepticism about possible future engagement was expressed on the basis of the seeming unsustainability of some of the earlier support.

Participants agreed that in assessing the status of a NARS it is helpful to do so from a perspective of a broad agricultural innovation system (chapter 1). Such a system spans many actors, **public** such as research organizations at levels from provincial to international (including, of course, national research and higher education entities), **private** such as farmers themselves and their organizations, as well as farm input suppliers and farm output processers and other actors in agricultural value chains, and **community**-based and non-government organizations. An effective national agricultural research institute (NARI), for instance, must work synergistically with all these other partners as well as advisory services, although all too often it seems such cooperative activity is under-attended or even absent. Managers face on-going challenges in effectively fostering the linkages that can enable the synergies to be exploited. Crafting appropriate governance arrangements is important in setting favorably the prospects for collaborative progress.

Just as the economic and political environment in which NARS function evolves over time, so too must the elements of NARS themselves. **New skills and facilities are required** in research entities if they are to respond to changing demands for research products to drive productivity growth in farming systems, and new managerial arrangements in such entities are required to enable such responses to be made efficiently (chapter 2). Research entities typically require dynamic adjustments in their resources to meet adequately the **emerging scientific opportunities** and the perceived imperatives for stimulating economic growth, reducing poverty, protecting the environment and assisting farmers in adapting to changing climate (chapter 3). Participants in this Roundtable process observed that **many NARS around the world had not been doing well in taking up these many challenging adjustments**, and seemed often to need assistance in moving forward. Participants argued that among the most critical aspects of NARS deserving strong support were fostering leadership and advancing management skills, areas that had been focal thrusts at ISNAR[16] and seemingly warranting a new champion.

Part of the explanation for the less than ideal situation observed in many parts of the world is the **low levels of investment in NARS** that persist, whether driven by tight fiscal realities and/or lack of political will to fund public agricultural research entities. At the same time, absent intellectual property protection and enforced commercial law often hold back private investment in R&D and constrain public-private partnerships (PPPs) (chapter 4). Moreover, in many countries there has been something of a "boom or bust" in NARS development as donor support has waxed and waned, and since **research is such an intrinsically long-term process**, such instability in resource provision often compromises the expected

[16] ISNAR is the acronym for the International Service for National Agricultural Research, a CGIAR Center that operated in The Hague from 1980 to 2004 and as a Program of IFPRI subsequently until 2009 when it was reorganized and renamed as the Knowledge, Capacity and Innovation Division of IFPRI. http://www.isnar.cgiar.org/

R&D impact. A crucial part of the situation pertains to the diverse but often too limited contributions of higher education institutions within the NARS. Another part of the explanation is attributable to insufficient exploitation of persuasive evidence of the achievements of past investment in agricultural research. Chapter 4 also speaks to the imperative of all concerned to do a better job of plausibly **assessing impacts of investments** in NARS and communicating (perhaps through more effective journalism, among others) the achievements to stakeholders, irrespective of the source of funding of such investment. Since this is a remarkably under-attended aspect, perhaps USAID should target both capacity development and technical assistance in this domain, which can assist in both accountability and learning aspects of NARS development.

The **management and organization of NARS,** including the often weak links from the NARS to other sectoral components such as agricultural advisory services and all of the private sector elements of the sector, is intrinsically a rather complex topic, several aspects of which are canvassed in chapter 5. Arguably, there has been global underinvestment in this domain. A major endeavor was the CGIAR effort through ISNAR, in its two incarnations. Observers, including those participating in the Roundtable, have diverse opinions about the success or otherwise of the "global" public investment in ISNAR. But what is uncontroversial is that many of its products are highly worthy (e.g., as assessed by Anderson et al. 2003) and have enduring value that should not be ignored in contemporary contemplation of support for NARS. The Literature Collection prepared in conjunction with this paper presents much of this cogent material in summary form. The main insights are summarized in chapter 5.

Fashions in agricultural research have varied greatly over recent decades (chapter 6), as stakeholders ranging from donors to concerned active participants in the NARS of developing countries have sought to learn from experience and to find ways to make the future better than the past. An enduring lesson of the past three decades has been **the criticality of NARS engaging with the broad farmer and value chain clientele**, across all the relevant groups of farming communities, especially the poor and disadvantaged. The era of focus on framing systems research is reflected upon in chapter 6 and attention is given to the more recent approaches to value chain research in order to guide a potential change in the recent USAID emphasis on agribusiness towards broad NARS (Agricultural Innovation System) support.

The core of the USAID concern addressed in this paper, **NARS capacity**, is taken up in chapter 7 under two themes on which the Agency has been outstandingly active in the past, **namely human capacity and institutional capacity**. USAID's ability to call upon the extensive resources of the Land Grant Universities (LGUs) was central to providing much of the advanced training of the research staff of the NARS built up with much other institutional support by the Agency in the 1960s and following decades. But with the flagging investment in many NARS (chapter 4), there has been **insufficient maintenance of both the human and infrastructural resources** (including libraries and laboratories, and even socio-economic and policy research units), and insufficient investment in new facilities such as computers and ICTs and modern laboratory equipment.

Naturally **the needs for strengthening capacity vary greatly according to country circumstance**. Large economies can readily enough afford to maintain and develop their NARS, and some do so handsomely, such as Brazil and China. Indeed, such strong NARS can and do provide significant" South-South" assistance in agricultural research. Many smaller economies will never be able to afford NARS that are in any sense comprehensive. Rather, they should **focus on building capacity to capture spill-ins from the work of others**, whether the "others" hail from nations of the North or South, the CGIAR or Regional entities, or in the private sector, including multinationals. Some aspects of capacity are not expensive and rather merely require political will, such as updating and harmonizing regulations pertaining to trade in seed and agricultural chemicals. Others, such as implementing effective capacity for managing biosafety are more costly and may require external assistance for effective implementation. But relevant national capability is critical to achieving growth in agricultural productivity everywhere, and needs for building capacity must be addressed accordingly.

An important first step in contemplating appropriate assistance for capacity strengthening is a cogent **assessment of the situation** that prevails. Such assessment itself may well be assisted by USAID Missions, which can help national authorities arrange for frank appraisal of the status of the NARS. In a few cases (e.g., Pakistan) such assessments have recently been made with USAID assistance, in others IFIs such as the World Bank have conducted relevant updates (e.g., Sri Lanka, Uruguay). In most cases the data assembled by ASTI can form a ready basis for developing an assessment. These data already document many contemporary problems, such as the crisis emerging with the imminent or recent retirement of many senior scientists in NARIs that were supported in earlier enlightened times.

An assessment should cover all aspects of the NARS that affect its performance through seeking good answers to questions such as the following. Do the public NARIs have the ability to attract and maintain the best scientists, which may be partly related to noncompetitive salaries and partly to unfavorable work environments? Are procedures adequate for identifying in agricultural systems those research problems of high priority and properly in demand? **Are incentives in place** to permit NARIs to respond to demand? Is appropriate use made of performance-based contracting? Are there adequate incentives to work with farmers and other value chain actors to solve significant problems? Has the "right" level of decentralization been reached in the NARS arrangements? Is the NARI operating budget sufficient? Can a good and well-motivated NARI scientist effectively attract the needed budget? Can public research entities work effectively with private ones? And with universities, including those in the US? How effective are the **arrangements for monitoring and evaluation**? How well is research-based information shared with stakeholders?

In tackling such non-trivial questions it will be helpful for an assessment team to interact with analysts from the **Ministry of Finance** or equivalent body, perhaps even through team membership, given the importance of such bodies in allocating resources for the public elements of a NARS. Parliamentarians should also be engaged. Similarly, and especially if an assessment is to include appraising the possibilities of alternate sources of funding for research, it would useful for the team also to engage with **farmer/farm-industry organizations** that could well be direct sources of funding (e.g., as in Uruguay). Some novel research-funding opportunities are not necessarily specific to agriculture. For example, general science, technology and innovation policies can play an important role in creating new funding opportunities, with notable examples in Brazil and Chile.

The scope of NARS assessment should also extend to the higher education sector. This is not only because national universities will be crucial for training the future research workers of the NARS but also because (perhaps largely through access to competitive research grants) the **universities should be playing an active role in the research enterprise of the NARS**. Universities will likely also play important parts in research collaboration that USAID may support between NARS and advanced research institutes in the US and elsewhere. Long-standing collaborative activities such as the CRSPs that have been supported by the Agency should, of course, be continued.

It is timely indeed for **USAID to re-engage in supporting NARS**, as most NARS in the developing world are sorely in need of assistance. Some assistance has been on-going, as in the indirect help via the CGIAR Centers and Programs, although in recent decades little of this has been for human-capacity development per se, a theme that might well be revisited by CGIAR decision makers.

Most future USAID assistance (including for work at the regional level) is destined to be delivered through the USAID Missions through national programs. It is to be hoped that Missions will focus on countries that commit to institutional reforms and where the enabling environment for agricultural research is supportive. Missions must develop their own mechanisms for identifying potential priorities for investing in agricultural development, including **assessing the needs for NARS capacity enhancement**. It is the authors' hope that the materials assembled in this Roundtable process will be helpful in such planning for productive engagement and investment.

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ANNEX 1: ROUNDTABLE PARTICIPANTS

Name	Organization
Gary Alex	USAID
Jock R. Anderson	Consultant/Academia/ex-World Bank
Irene Annor-Frempong	FARA (Director, NARS Capacity Training)
Jill Barr	CIRAD
Nienke Beintema	IFPRI (Head of the ASTI initiative)
Larry Beach	USAID
Rob Bertram	USAID
Rupert Best	Catholic Relief Services
Arvin Bunker	Weidemann Associates
Clara Cohen	USAID
Montague Demment	Association of Public Land Grant Universities
Rubin Echeverría	CIAT (Director General)
Marco Ferroni	Syngenta
Elon Gilbert	Independent Consultant
Steve Haggblade	Michigan State University
Doug Horton	Consultant/ex-ISNAR
Julie Howard	USAID
Josette Lewis	Arcadia/Private Sector
Hector Hugo Li Pun	FORAGRO/IADB
Sohail J. Malik	Senior IFPRI collaborator/NARS Pakistan
Joyce Mook	Senior Advisor to the Gates Foundation
David Nielsen	World Bank
Phil Pardey	University of Minnesota
Suzanne Poland	USAID
Cathy Ragasa	IFPRI
Brenna Ranzen	Weidemann Associates
Han Roseboom	Consultant/ex-ISNAR
Elizabeth Skewgar	USAID
David Spielman	IFPRI
Kerri Wright Platais	World Bank consultant

ANNEX 2: BRIEF SUMMARY OF SURVEY RESULTS

A survey was conducted among four types of actors: (i) NARS leaders; (ii) International and (sub-) regional NARS Organizations (i.e., GFAR, FARA, APAARI, etc.); (iii) Bilateral and multilateral donors; and (iv) Development practitioners. This Annex summarizes the principal findings of this survey.

1. Importance of NARS:

    a. A critical but not sufficient condition to achieve economic growth, poverty reduction, food security, and environmental sustainability.
    b. NARS have to be seen in the context of an AIS perspective.
    c. The technology acquisition and validation role of NARS needs to be strengthened. For small-country NARS this role is more important than technology generation as such.
    d. Innovations in agriculture are becoming increasingly complex and systemic; requiring a lot more coordination between different actors and stakeholders → this requires the adoption of an AIS approach.

2. NARS constraints:

    a. Funding.
    b. Human resources. Many NARS are struggling with the exodus of experienced scientists due to retirement.
    c. Weak linkages within NARS: In particular universities are often poorly integrated in the NARS. Also 'private sector' research is not well integrated into most NARS.
    d. Weak external linkages: Links of research with extension and the private sector (farmers, processors, traders, input suppliers, etc.) still weak in most countries.
    e. Weak responsiveness to the needs of the agricultural sector.
    f. Lack of policies (and coordination between policies) to facilitate and stimulate agricultural innovation and/or lack of implementation capacity to enforce such policies.
    g. Lack of critical mass in many of the smaller NARS.
    h. Lack of political support.
    i. Too much dependence on public support.
    j. Compartmentalization of research.
    k. Weak leadership and management.
    l. Weak governance (e.g., underrepresentation of farmers on the boards of research organizations).
    m. Weak planning and M&E.
    n. Weak culture of sharing information.
    o. Too much supply-driven and not demand-driven.

3. Good practices:

    a. Introduction of instruments that focus more on output and performance such as performance-based contracts (NARO, Uganda) and competitive funding schemes (many countries). However, the use of such instruments requires a change in culture.
    b. Farmer funding and farmer governance of agricultural research (Uruguay and Australia).
    c. Incentive schemes for researchers (China and Brazil).
    d. The adoption of a value chain approach and a better understanding of markets.

e. Stakeholder participation (farmers, but also other actors along the value chain) in the various steps of the research process (problem identification, priority setting, funding, research implementation, and technology validation and transfer).
f. Decentralization of agricultural research – although one should be careful not to push it too far.
g. Better links with NGOs and development projects have helped to enhance impact in farmer fields.
h. Adoption of integrated system approaches.
i. Public-private partnerships (PPPs) leveraging more private resources (including specific taxes) towards agricultural research.
j. M&E built around 'learning' and not 'policing'.
k. CAADP process in Africa has given substantially more urgency to the need to invest in agriculture and in agricultural innovation.
l. The introduction of the innovation concept.

4. NARS actions needed:

    a. Strong advocacy to increase investment in agricultural research, extension and education.
    b. Reform of governance structures.
    c. Building a culture of accountability and responsiveness to client demand.
    d. Strengthening of internal as well as external linkages, including linkages with other NARS and IARCs.
    e. Introduction of instruments that facilitate collaboration between the different NARS actors as well as with external innovation partners.
    f. Institutional autonomy in order to enter into contractual relationships with third parties.
    g. Adoption of an innovation system approach and promotion of multi-stakeholder interaction and partnerships.
    h. Capacity strengthening (both human and institutional).
    i. More emphasis on up scaling of research results and technology transfer.
    j. Greater productivity enhancement is needed to off-set rising food prices.
    k. NARS will have to develop adequate responses to climate change effects on agricultural production.

5. USAID support to NARS

    a. USAID has historically been a strong supporter of NARS development. In recent years, however, USAID support to NARS has been more indirect through: (a) programs targeting specific value chains or themes; and (b) funding of (regional) competitive funding schemes. There is hardly any USAID support to NARS in the LAC and CAC regions.
    b. Providing training opportunities for NARS scientists.
    c. Linking NARS scientists with US scientists for collaborative research.
    d. NARS support should be driven by an AIS perspective and linked up to regional initiatives such as CAADP, regional productivity programs, etc.
    e. NARS capacity development is a long-term commitment. Its impact is not immediate, but long-term.

6. Specific strengths of USAID
    a. Long-standing success of CRSPs should be continued.

b. US universities can play a crucial role in the development of universities in developing countries. They have in particular a lot of expertise in new education technology.
c. US universities can be attractive partners in national research programs that require advanced research inputs that cannot be sourced locally.
d. US universities and research institutes have a strong track record with regard to productivity enhancement of food crops and value chain development, but less so with regard to mitigating climate change effects.
e. Human and institutional capacity building through long-term collaborative arrangements (instead of ad hoc, one-shot consultancy approaches many other donors use). Capacity building requires a long-term and sustained engagement.
f. Promotion of linkages with technology transfer agencies.
g. Help NARS to better understand and apply R&D approaches that integrates markets, productivity and policy.
h. Establishment of platforms that integrates research, extension, private sector and policy.

7. Lessons learned from past USAID assistance by NARS

    a. There is no culture to learn from past experiences. The same mistakes tend to be made over and over.
    b. Both USAID and the recipient country should think in advance about the post-support phase. In too many cases, advances in capacity building are not sustained after donor assistance is withdrawn.
    c. USAID support to research networks has been quite successful and much appreciated.

8. Suggested priority areas for USAID to focus on:

    a. Training.
    b. Organization and management.
    c. Internal and external linkages (including the establishment of institutional-financial mechanisms to improve the interactions among the actor of the system).
    d. Funding of research projects and programs.
    e. Policy.
    f. Infrastructure.
    g. Assistance with new and upstream research areas (biotech, nanotechnology, etc.).

9. NARS assessments

    a. External review PARC, Pakistan (2012) / IFPRI
    b. Assessment INIA, Uruguay (2011) / World Bank
    c. Chile (2010/2011) / World Bank
    d. Peru (2013) / World Bank
    e. Bolivia (2010) / World Bank
    f. Sri Lanka (2007) / World Bank
    g. India (2005) / World Bank
    h. India: (i) APAARI, ICRISAT and NCAP. 2005. Research need assessment and agricultural research priorities for South-Asia and West Asia, Proceedings of a Workshop held at ICRISAT, 7-8 October, 2004; (ii) Singh, R.B. 2009. Regional Report on Agricultural Research for Development in the Asia-Pacific Region. APAARI, ADB and GFAR. New Delhi; (iii) Mruthyunjaya and Praduman Kumar. 2010. GCARD Regional

Review for Asia Pacific, South Asia Report. APAARI, ADB and GFAR; (iv) Mruthyunjaya. 2012. Prioritization of Demand-Driven AR4D in India (APAARI, IFPRI and ADB); (v) Government of India, Planning Commission. 2011. Working Group Report on Agricultural Research for the 12th Five Year Plan (2012-17).

ANNEX 3: KEY REFERENCES

Abstracts, Grouped by chapter of the Issues Paper

Chapter 1: Evolving NARS perspective

Chema, S., E. Gilbert and J. Roseboom. December 2003. *A Review of Key Issues and Recent Experiences in Reforming Agricultural Research in Africa*. ISNAR Research Report No. 24. The Hague: ISNAR.

ftp://ftp.cgiar.org/isnar/publicat/pdf/RR-24.pdf[17]

This paper argues that NARS reforms are being shaped by three factors: (i) Changes in the external environment of the NARS; (ii) Feedback from NARS performance assessments; and (iii) Schools of thought. In this case two schools of thought were identified as shaping the NARS reform agenda in SSA in particular, namely: 'AKIS' and 'new public management'. Although most of the reforms in the early 2000s were implemented under the AKIS concept, the first signs of the emerging AIS approach were already on the wall.

NARS (1980s/1990s)

World Bank. 1981. Agricultural Research Systems: Sector Policy Paper. Washington DC: World Bank.

[The 1981 Sector Policy Paper on Agricultural Research is a small volume of 110 pages, many of which detail earlier World Bank operations in this subsector. There is a seven page section of Summary and Recommendations, which inter alia include the rather qualified advice about having some 2% as a target agricultural research intensity. This "Abstract" presents some selected sections from the summary (extracted by Jock R. Anderson in January 2013). Remarks other than direct quotations are in [ ]. The original document was prepared by Theodore J. Goering drawing on inputs from staff and consultants.]

For much of the developing world, it can be concluded, investment must be significantly expanded to improve the capacity to conduct agricultural research if these targets [of needed agricultural growth] are to be achieved. The objective of the paper is to provide information and policy guidance of relevance to those efforts. (Issues Paper page 5)

National research programs are typically the weakest links in the global research effort. Common deficiencies include excessive fragmentation of research activities among government agencies, low priority accorded to research by governments, and inadequate institutional structures for research and extension. The limited research capacity of many national systems also limits the returns to investment in the international research centers. There is a need to strengthen the administrative and technical capability of national systems through expanded training programs. Assuming that at least 100,000 ha of a particular crop are required to justify a significant research effort at the country or regional level, an approximate doubling of the present number of research scientists would be needed in developing countries. Training programs would have to be expanded significantly if these staffing requirements were to be met and must be accompanied by more generous financial rewards to the agricultural research scientists in order to retain them in research activities.

[17] When free links are available they appear immediately after the document citation.

External assistance to strengthen national systems must take into account the size of the country's agricultural sector and the current state of development of its research system. Perhaps 10 percent of developing countries already have adequate research skills, good national research programs, and effective linkages with international research institutions. These countries may be able to provide assistance to other countries with weak research programs. Another 10 percent of the developing countries have adequate research expertise, but it frequently is poorly organized and managed. For this group of countries, external assistance in research organization and management may be required. Nearly half of all developing countries are large enough to justify and support a balanced national research system but lack essential research infrastructure. The needs of those countries are to develop an effective organization for research, to acquire proper research facilities, and to strengthen the scientific manpower base to conduct research. The remaining countries have very limited research resources and no single crop of sufficient importance to warrant a complete research system. For these countries, the major need is to develop a limited capability for research, largely of an adaptive nature, for a small number of economically important crops.

The World Bank's support of agricultural research and extension takes several forms: (a) agriculture and rural development projects that contain adaptive research and extension components; (b) national or statewide adaptive research and extension projects; (c) research components in education projects; and (d) financial and administrative support of the CGIAR. In fiscal 1977-79, lending for research and extension, as embodied in the first three categories, constituted almost 9 percent of total Bank lending for agriculture and rural development. In recent years about 30 percent of this proportion has been allocated to research alone.

In a number of countries, national research programs are weak and, therefore, not able to adapt fully to utilize technologies being developed by the international research community. A rational allocation of financial resources for research on a global basis requires substantial increases in funds to strengthen national programs and to complement any further expansion of the international system. A desirable investment target for research in many countries with poorly developed agricultural research systems would be an annual expenditure (recurrent, plus capital) equivalent to about 2 percent of agricultural gross domestic product (GDP). The rate at which annual expenditures can be increased and efficiently utilized will depend on several factors, including the absolute size of the existing system, as well as the relative size (i.e., research expenditure as a percent of agricultural product), availability of qualified technical staff, and the financial capacity of a system to support a larger national effort.

Taking these resource and institutional considerations into account, growth rates for expenditures on agricultural research in developing countries of at least 10 pc a year would be appropriate.

[Some remarks pertaining to the post-1980 period to the end of fiscal 1984] By the end of this period, these amounts will be divided about equally between research and extension. A substantial portion of the increase in funds will be used for expanding the production of food crops that are important to small farmers and to lower-income consumers. Agricultural research projects should pay more attention to nutritional aspects. Where appropriate, the research projects can focus on food production systems that are relevant to the diets of the poor; on farming systems in relatively neglected or resource-poor areas; on applied and adaptive research that is directly applicable to farmers' production problems; on the development of effective organizational structures for research and extension; and on the examination of the ecological consequences of sustained, high-input production systems.

The Bank will also support, on a selective basis, more fundamental or basic research where the potential benefits warrant the long lead time and heavy commitment of resources that frequently characterize these research endeavors. The Bank will increase its support for sectoral lending to national research grams. Where borrowing countries pursue supportive policies, the Bank will be prepared to consider providing continued technical and financial support for program of 10-15 years in the form of "repeater" projects

that build on the initial investment. Among low-income countries, suitable financing arrangements will need to be provided; such arrangements should include funding by the Bank of an appropriate portion of incremental operating expenses of national research projects.

An increase in the number of specialized staff is likely to be needed in the Bank in order to support efforts to strengthen national research systems. The Bank and borrowing countries will also need to utilize more fully the services of other national and international organizations, including the international research centers, in the preparation and supervision projects. The Bank will also provide a more comprehensive treatment of issues concerning agricultural research in its agricultural sector studies. This sector work will address the adequacy of national research systems and examine the appropriateness of national economic policies that bear upon the generation and adoption of improved technology."

The recommendations made in this paper, when taken together, establish a solid basis for an expanded research effort that promises attractive economic and social benefits. But the expanded support is likely to be of limited usefulness unless borrowing countries accord high priority to national agricultural research by providing adequate financial support and appropriate economic and other policies that encourage the adoption of improved technologies and that, above all, establish hospitable work environments for national research scientists and administrators. (p.11, as the end of the summary)

Gamble, W.K. 1997. "The Globalization of Science: Agricultural Research in Developing Countries." Paper in *The Globalization of Science: The Place of Agricultural Research* (new, expanded edition), edited by C. Bonte-Friedheim and K. Sheridan. The Hague: International Service for National Agricultural Research.

http://pdf.usaid.gov/pdf_docs/PNACL207.pdf

Dr. Gamble served as the first Director General of ISNAR from 1980 until his retirement in 1985. Prior to that he was DG of IITA (1975-80) and served in various capacities on the agricultural research programs of the Ford Foundation throughout the developing world. In this paper he argued that "research is still focused on the generation of technology rather than on problem resolution, with an understanding of the economic consequences of the utilization of the technology. There is still much to be done in the areas of policy and political commitment, research scientist/client contact, population control, and reduction in poverty in the rural sector to enable developing countries to be active participants in the globalization of science."

For more ISNAR literature see chapter 5.

AKIS (1990s/2000s)

FAO and World Bank. 2000. Agricultural Knowledge and Information Systems for Rural Development (AKIS/RD): Strategic Vision and Guiding Principles. Rome: FAO and World Bank.

ftp://ftp.fao.org/SD/SDR/SDRE/AKIS.pdf

"An agricultural knowledge and information system (AKIS) links people and institutions to promote mutual learning and generate, share and utilize agriculture-related technology, knowledge and information. The system integrates farmers, agricultural educators, researchers and extensionists to harness knowledge and information from various sources for better farming and improved livelihoods. This integration is suggested by a "knowledge triangle" of research, extension and education. Farmers are at the heart of the knowledge triangle.

Education, research and extension are services – public or private – designed to respond to their needs for knowledge with which to improve their productivity, incomes and welfare and manage the natural resources on which they depend in a sustainable way.

A shared responsiveness to farmers and an orientation towards their goals ensures synergies in the activities of agricultural educators, researchers and extensionists. Farmers and other rural people are partners within the knowledge system, not simply recipients."

AIS (2000s/2010s)

Spielman, D.J. 2005. *Innovation Systems Perspectives on Developing-Country Agriculture: A Critical Review*. ISNAR Division Discussion Paper No. 2. Washington DC: IFPRI.

http://www.ifpri.org/sites/default/files/publications/isnardp02.pdf

"Innovation systems perspectives on agricultural research and technological change are fast becoming a popular approach to the study of how society generates, disseminates, and utilizes knowledge. The innovation systems literature represents a significant change from the conventional, linear approach to research and development by providing an analytical framework that explores complex relationships among heterogeneous agents, social and economic institutions, and endogenously determined technological and institutional opportunities. Recent empirical work extends the innovation systems approach from studies of national innovation systems in industrialized-country manufacturing to developing-country agriculture, and shifts the emphasis from a unidirectional technology transfer approach to a more complex, process-based systems approach. This shift in perspective is appropriate for the study of developing-country agriculture because it captures the intricate relationships between diverse actors, processes of institutional learning and change, market and nonmarket institutions, public policy, poverty reduction, and socioeconomic development.

Early applications of the innovation systems framework to developing-country agriculture suggest opportunities for more intensive and extensive analysis. There is ample scope for empirical studies to make greater use of the theoretical content available in the literature, and to employ more diverse methodologies, both qualitative and quantitative. Further, there is room to improve the relevance of empirical studies to the analysis of public policies that support science, technology, and innovation, as well as to policies that promote poverty reduction and economic growth. This paper attempts to examine these issues with respect to recent applications of the innovation systems framework to developing-country agriculture, and suggests several ways to strengthen the mode of inquiry and quality of analysis.

The paper begins by tracing the literature on innovation systems from its roots in evolutionary economics and systems theory, followed by a review of recent applications to developing-country agriculture. This discussion is followed by the presentation of a model of an innovation system derived from a series of game theoretic and population game models in which heterogeneous agents interact and evolve through strategic patterns of behavior. The paper then reviews the strengths and weaknesses of recent applied work in developing-country agriculture and concludes with recommendations for improving analytical strength, relevance to public policy, and relevance to poverty reduction."

World Bank. 2006. Enhancing Agricultural Innovation: How to Go Beyond the Strengthening of Research Systems. Washington, DC: World Bank.

http://siteresources.worldbank.org/INTARD/Resources/Enhancing_Ag_Innovation.pdf

"This paper seeks to assess the usefulness of the innovation systems concept in guiding investments to support the development of agricultural technology. To that end, it develops an operational agricultural innovation systems concept for the Bank's client countries and collaborators. This paper does not

challenge the importance of investing in science and technology capacity, which is well recognized in innovation systems theory. Rather it focuses on the *additional insights* and *types of interventions* that can be derived from an innovation systems perspective and that can influence the generation and use of science and technology for economic development."

World Bank. 2012. Agricultural Innovation Systems: An Investment Sourcebook. Washington, DC: World Bank.

http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTARD/0,,contentMDK:23129039~pagePK:148956~piPK:216618~theSitePK:336682,00.html

This sourcebook is a compilation of the state-of-the-art thinking on agricultural innovation systems in developing countries. More than 70 authors contributed to this publication. It comprises the following seven modules:

1. Coordination and collective action for agricultural innovation;
2. Agricultural education and training to support agricultural innovation systems;
3. Investment in extension and advisory services as part of agricultural innovation systems;
4. Agricultural research within an agricultural innovation system;
5. Incentives and resources for innovation partnerships and business development;
6. Creating an enabling environment for agricultural innovation; and
7. Assessing, prioritizing, monitoring, and evaluating agricultural innovation systems.

Klerkx, L., B. van Mierlo and C. Leeuwis. 2012. "Evolution of systems approaches to agricultural innovation: concepts, analysis and interventions." Chapter 20 in *Farming Systems Research into the 21st Century: The New Dynamic*, edited by I. Darnhofer, D. Gibbon and B. Dedieu.

http://www.academia.edu/1569316/Evolution_of_systems_approaches_to_agricultural_innovation_Concepts_analysis_and_interventions

"Over the years, there has been an evolution of systemic thinking in agricultural innovation studies, culminating in the agricultural innovation systems perspective. In an attempt to synthesize and organize the existing literature, this chapter reviews the literature on agricultural innovation, with the threefold goal of (1) sketching the evolution of systemic approaches to agricultural innovation and unraveling the different interpretations; (2) assessing key factors for innovation system performance and demonstrating the use of system thinking in the facilitation of processes of agricultural innovation by means of innovation brokers and reflexive process monitoring; and (3) formulating an agenda for future research. The main conclusion is that the agricultural innovation systems perspective provides a comprehensive view on actors and factors that co-determine innovation and in this sense allows understanding the complexity of agricultural innovation. However, its holism is also a pitfall as it allows for many interpretations, which complicates a clear focus of this research field and the building of cumulative evidence. Hence, more work needs to be done conceptually and empirically."

This chapter provides a more in-depth discussion of AIS and its evolution and various interpretations.

Smits, R.E., S. Kuhlmann and P. Shapira. 2010. *The Theory and Practice of Innovation Policy: An International Research Handbook*. Cheltenham, UK: Edward Elgar Publishing.

"This comprehensive handbook explores the interactions between the practice, policy, and theory of innovation. The goal is twofold: to increase insight into this dynamic process, searching for options to improve the effectiveness and efficiency of both policy and innovative practice; and (ii) to identify conceptual or empirical lacunae and questions that can guide future research."

Although not addressing agricultural innovation in developing countries, this book is a good starting point for those who are interested in learning more about innovation systems and innovation policies in general.

European Commission. 2012. *Agricultural Knowledge and Innovation Systems in Transition – a reflection paper.* Brussels: European Commission, Standing Committee on Agricultural Research.

http://ec.europa.eu/research/agriculture/scar/pdf/akis_web.pdf

This publication gives an overview of A(K)IS thinking within the European Union. EU countries are at quite different stages in terms of absorbing AIS ideas and concepts.

Chapter 2: Economic and political structural changes affecting NARS

The transformation of the agro-food value chain and its impact on innovation patterns

Roseboom, J. 2003. "The Contribution of Agricultural Input Industries to Agricultural Innovation." *International Journal of Agricultural Resources, Governance and Ecology* Vol. 2, No. 3/4 (2003): 295-311.

This paper brings together three ideas, namely: (i) as economies develop, the forward and backward linkages of primary agricultural production become a lot stronger; (ii) the existence of technology spill-overs between industries; and (iii) input-output matrices can be used to trace such technology spill-overs. Based on three cases (Brazil, Colombia and the Netherlands), the author estimates the amount of R&D investment that primary agriculture obtains through buying inputs from various local and foreign industries and relates this R&D spill-in to R&D investments in primary agricultural production itself. This results in agricultural technology intensities that differ quite significantly between the three countries, but which, as expected, increase with income-per-capita. The more interesting finding, however, is that the composition of the underlying innovation sources differs quite markedly and follows a rather unexpected pattern. In relative terms, agriculture in the poorest country (Colombia) stands out as the most dependent on innovation that is privately financed, imported, and non-agricultural. Brazil takes just the opposite position and the Netherlands sits in between.

Morris, M.L., ed. 1998. *Maize Seed Industries in Developing Countries*. Boulder, Colorado: Lynne Rienner Publishers.

This book argues that, despite an enormous diversity in maize seed industries across countries, there are recurring patterns of growth and development. The fact that these patterns appear over and over suggests that despite having unique features, every maize seed industry develops in a certain predictable way.

Future Agricultures Consortium. 2012. *The Political Economy of Cereal Seed Systems in Africa's Green Revolution*. Policy Brief 44. Brighton, UK: Future Agricultures Consortium Secretariat.

http://www.future-agricultures.org/publications/research-and-analysis/policy-briefs/doc_download/1536-the-political-economy-of-cereal-seed-systems-in-africas-green-revolution

Drawing on lessons from case studies from Ethiopia, Ghana, Kenya, Malawi and Zimbabwe conducted by the Future Agricultures Consortium during 2009-11, this Policy Brief assesses the political economy of cereal seed system R&D programs and processes across Sub-Saharan Africa. By examining the contrasting politics and different configurations of interests affecting the way cereal seeds are produced and delivered in these countries, it identifies opportunities for reshaping the terms of the debate and opening up alternative pathways (i.e., alternative to the market approach promoted by most donors) towards more sustainable and socially just seed systems.

Reardon, T. and A. Gulati. 2008. *The Super Market Revolution in Developing Countries*. IFPRI Policy Brief No. 2. Washington, DC: IFPRI.

www.ifpri.org/sites/default/files/publications/bp002.pdf

"A "supermarket revolution" has been underway in developing countries since the early 1990s. Supermarkets (here referring to all modern retail, which includes chain stores of various formats such as supermarkets, hypermarkets, and convenience and neighborhood stores) have now gone well beyond the initial upper- and middle-class clientele in many countries to reach the mass market. Within the food system, the effects of this trend touch not only traditional retailers, but also the wholesale, processing, and farm sectors. The supermarket revolution is a "two-edged sword." On the one hand, it can lower food prices for consumers and create opportunities for farmers and processors to gain access to quality-differentiated food markets and raise incomes. On the other hand, it can create challenges for small retailers, farmers, and processors who are not equipped to meet the new competition and requirements from supermarkets. Developing-country governments can put in place a number of policies to help both traditional retailers and small farmers pursue "competitiveness with inclusiveness" in the era of the supermarket revolution. Some countries are already taking such steps, and their experiences offer lessons for others."

Bio-based economy

Asveld, L., R. van Est and D. Stemerding, eds. 2011. *Getting to the Core of the Bio-economy: A Perspective on the Sustainable Promise of Biomass.* The Hague, The Netherlands: Rathenau Institute.

http://www.rathenau.nl/uploads/tx_tferathenau/Report_Biobased_Economy_01.pdf

This study explores how the Dutch economy can make the transition from a fossil-based to a bio-based economy and what type of obstacles can be expected. It makes the point that just 150 years ago the Dutch economy embarked on a profound transformation in the opposite direction – from a bio-based to a fossil-based economy. The Dutch government is strongly committed to the idea of a bio-based economy and operates at the forefront of this type of thinking (together with the USA and Brazil).

One interesting issue is how are we going to organize bio-refinery – locally on-farm or centralized? If the former, this could result in a far more decentralized industrial production landscape.

ETC Group. 2011. 2011. *Who will control the Green Economy?* ETC Group Communiqué No. 107. ETC Group.

www.etcgroup.org/sites/www.etcgroup.org/files/publication/pdf_file/ETC_wwctge_4web_Dec2011.pdf

The ETC Group (previously RASFI) is an international lobby organization based in Canada that works to address the socioeconomic and ecological issues surrounding new technologies that could have an impact on the world's poorest and most vulnerable people. The report tries to document how the world's largest companies are preparing themselves for a bio-based economy and the concentration of commercial and technological power that may result.

"The world's largest companies are converging around biomass in anticipation of a post-petrochemical future. That doesn't mean they're simply grabbing land and natural resources; they're also investing in new technology platforms to transform plant-derived sugars (from food and fibre crops, algae, and all kinds of plant matter) into industrial products. The gravitational pull of biomass is creating new constellations of corporate convergence across diverse industry sectors."

Democratization and decentralization

Wennink, B. and W. Heemskerk, eds. 2006. Farmers' Organizations and Agricultural Innovation: Case Studies from Benin, Rwanda and Tanzania. Amsterdam: Royal Tropical Institute (KIT).

www.kit.nl/net/KIT_Publicaties_output/ShowFile2.aspx?e=1561

Research and extension organizations have moved from working with individual farmers to collaboration with groups and, increasingly, with farmers' organizations. At the grass-roots level, farmers' associations, producers' groups and cooperatives, as well as specially created farmers' groups, are all involved in research and extension activities. At higher levels, unions, federations and syndicates are implicated in multi-stakeholder platforms for planning research and extension services. Nowadays farmers' organizations (FOs) present a highly diverse picture: from the former, state-managed, cooperative societies and unions to the new, farmer-initiated federations and syndicates, as well as market-driven farmers' groups. As a consequence, links with public and private knowledge-for-innovation service providers are encountered at all levels, with various status, aims and functional modalities. But the role of FOs in agricultural innovation goes much further than simply participating in, and contributing to, research and extension. Support functions, such as guiding innovation processes (e.g., information on norms, regulations and markets), sharing experiences for learning purposes, and providing complementary services (e.g., credit facilities), are equally important. FOs can therefore fulfil several roles, contribute to various functions that enhance successful innovation and increasingly provide services themselves.

This study analyses the roles played by FOs in agricultural innovation using the innovation systems concept and investigates the constraints that hamper them from playing their role to the fullest extent. Case studies were conducted, in partnership with farmers' organizations, as well as research, extension and training institutions in Benin, Rwanda and Tanzania. The case study approach also highlighted a number of best practices and lessons learned. Finally, research findings allowed the teams to identify the main issues for strengthening the role of FOs in agricultural innovation systems.

The case studies show that FOs operate in the changing context of an increasingly pluralist service provision sector, in which the public-sector research and extension institutions are being deconcentrated and the private-sector service providers (e.g., enterprises, NGOs, and farmers' organizations) are developing a market share. FOs are also increasingly valued for representing social capital that is crucial for the necessary transformation of the African agricultural sector. However, the way in which FOs seize these newly created opportunities are determined by their origin and history.

According to the nature of the investments used to build the organizations and the types of links that are being pursued by the FOs, three types of farmers' organizations can be distinguished:

1. 'Old' commodity-based FOs (e.g., FUPRO Benin and its member unions, but also out-growers associations) have been created through the initiative of (and with assistance from) parastatals or private enterprises. They have established contract-type relationships with private enterprises for input supply and marketing of produce. Innovation is mainly technological and oriented by the commodity market and the private sector.
2. 'New' market-oriented FOs with 'collaborative' relationships (e.g., ACooBéPA Benin and IMBARAGA-affiliated potato producers' federations) seek to develop collaboration with chain actors, using assistance from externally funded projects and/or NGOs (which often initiated the creation of the FO). Innovation remains technological if the project and NGO manage relationships (e.g., Benin case) but becomes institutional (e.g., Rwanda case) when both NGO and FO clearly aim to build sustainable institutions.

3. Service-system-oriented and network FOs (e.g., MVIWATA and MVIWAMO in Tanzania, but also IMBARAGA in Rwanda) emphasize self-reliance by promoting community-based farmers' groups that are also part of larger networks. Through collective action (social capital) and participating in local fora, they establish partnerships with other actors for service provision in various areas (information and training on technologies, credit and savings schemes, etc.). Innovation has a rather organizational and institutional character as a prerequisite for technological innovation.

The case studies demonstrate that FOs currently access various sources to gain knowledge and information from both the public and private sectors, and use those that are most appropriate to them. However, new links are not always formalized. In all cases, 'private goods' and related knowledge and information, such as agricultural inputs (seeds, fertilizers, pesticides, etc.), are increasingly seen as private-sector business. This compels public organizations to redefine their role in relation to the private sector; the latter often only serves part of the farming community. All FOs contribute to the so-called support functions within the agricultural innovation system, e.g. input supply, credit and savings schemes, and marketing of products. Farmers consider these services to be crucial for (technological) innovation. FO contributions to the so-called basic functions (research and extension) vary according to the type of organization involved. Commodity-based and market-oriented organizations studied consider research and extension as belonging to other institutes and organizations from both the public and private sectors. These are the main drivers behind innovation, despite the fact that the resource base, particularly of the commodity-based organizations, allows services to be oriented according to their membership's needs. However, service-system-oriented organizations play a much more active role in knowledge and information services, but in turn lack resources (and thus power) to set the agendas of these service providers.

Experiences indicate that FOs can play an important role in sharing knowledge-for-innovation by initiating multi-actor platforms for interactive learning and by implementing joint activity programmes (including use of the media) with extension services on a cost-sharing basis. A major challenge facing FOs is to develop sustainable funding mechanisms for these (farmer-led) initiatives.

Chapter 3: Pursuing emerging scientific opportunities and meeting old and new challenges

Scientific opportunities

ISNAR. 1992. *Future Challenges for National Agricultural Research: A Policy Dialogue*. Proceedings of the international conference entitled "Challenges and Opportunities for the NARS in the Year 2000: A Policy Dialogue," held in Berlin, 12-18 January 1992. The Hague: International Service for National Agricultural Research.

http://pdf.usaid.gov/pdf_docs/PNABM083.pdf

These conference proceedings are compilation of 14 papers presented at a high-level conference organized by ISNAR and DSE. They provide an overview of the challenges and opportunities for NARS as formulated some 20 years ago. Biotechnology and system approaches (e.g., integrated pest management) were at that time already prominently on the agenda as important opportunities but at the same time also as challenges (in particular biotechnology – i.e., biosafety and ownership issues). Interestingly, ICT is only being mentioned in the context of exchanging scientific information between research institutes. The application of ICT in agricultural production processes was not on the agenda yet – but keep in mind that in 1992 PC's had only just started to spread and mobile phones were still for the

happy few. There is no mention of nanotechnology or robotics as important technological opportunities at this conference – these are more recent developments.

In 1992, there is also no mention at the conference of biofuel or bio-based economy. This despite the fact that Brazil's bio-ethanol program, started in 1976, was well underway at that time. It was not seen at that time as a technology that would be picked up widely.

CGIAR Science Council. 2005. *Science for Agricultural Development: Changing contexts, new opportunities*. Rome, Italy: Science Council Secretariat.

http://library.cgiar.org/bitstream/handle/10947/3923/scienceforagrdev_science_council_2005.pdf?sequence=1

This report analyses recent trends, current status and emerging issues related to the application of science to agricultural production. In addition to genetics, informatics, and nanotechnology (but not robotics), it highlights the importance of 'integrated system approaches' to agricultural problems.

Serageldin, I. and G.J. Persley. 2000. Promethean Science: Agricultural Biotechnology, the Environment, and the Poor. Washington, DC: World Bank.

http://www.worldbank.org/html/cgiar/publications/prometh/pscont.html

This publication highlights the potential contribution that agricultural biotechnology can make to increase agricultural productivity and raise access to food in developing countries. In order this to happen, the following actions are urgently needed:

1. *"Plant and Animal Genomes*: Ensure that the descriptions of genomes of the world's agriculturally important species are genetically mapped and that this information is put in the public domain, able to be used widely to generate improved varieties and breeds adapted to local ecosystems, and useful biological products.
2. *Identify Priority Traits*: Identify the genes conferring traits that are important to poor producers in marginal environments. Some, such as drought tolerance in cereals, appear likely to be shared across species. This knowledge would greatly accelerate breeding for these difficult traits and enhance the ability of the target crops to be more productive in difficult environments.
3. *Conserve and Characterize Genetic Resources*: Maintain and characterize the farm animal and plant genetic resources of the world's major agricultural species. A recent review of the CGIAR's in vitro collections suggests that it will require US$70 million to upgrade the present plant collections, and thereafter US$8 million per year to maintain them. According to FAO studies, additional investments are required to collect, characterize, and conserve farm animal genetic resources. The collections of plant and animal genetic resources, and the biological information pertaining to them, are a vast resource for genetic improvement and the identification of useful traits. There is an urgent need to ensure that these collections are financed in a more sustainable way so as to ensure that the genetic resources of the world's major agriculture species are conserved, characterized, and accessible for use, in perpetuity.
4. *Access Enabling Technologies*: Obtaining access to proprietary technologies is key to the successful applications of biotechnology to agriculture in the developing world. This will enable the characterization and application of useful genetic information for crop and livestock improvement and the integrated control of pests, parasites, and pathogens.
5. *Establish Strategic Alliances*: A concerted international effort is needed to establish a new compact between the public and private sectors of the industrial and developing countries, so that the new developments in modern science are able to be used more effectively.

6. *Increase Investments in Agriculture*: Significant additional investments by the public and the private sectors are required if agricultural productivity is to increase in the developing world in an environmentally sustainable way.
7. *Provide Incentives for Private Sector Participation and Partnerships*: Incentives are needed to encourage the private sector to address the problems of agriculture and the environment in developing countries, for mutual benefit.
8. *Mobilize the Global Scientific Community to Address the Problems of Food for the Poor*: The CGIAR centers presently invest US$25-35m each year on agricultural biotechnology, out of a total CGIAR budget of US$340 million. The CGIAR centers and the national agricultural research systems are also the repository of a vast array of knowledge of the biology of the world's major food crops, livestock, fish, and tree species and their associated pests and pathogens. International crop improvement programs are located throughout the world's major ecosystems. These scientific, biological, and financial resources are a powerful platform. They now need to be mobilized with the global scientific community in new and imaginative ways, if a quantum leap is to be made in improving agricultural productivity, food access, and livelihoods by 2020. The Global Forum for Agricultural Research may play an important role here.
9. *Identify Desired Outputs*: Innovations that are required to contribute to improved food security and to create wealth in the poorer regions of the world include: Improved genotypes and better agricultural practices to ensure sustainable increases in productivity; new biological products, such as vaccines, biocontrol agents, and diagnostics for the control of major endemic diseases of crops and livestock. Achieving these outcomes will require marshaling and directing public and private financial and scientific resources in new ways, both nationally and internationally. Also, R&D advocated in the area of genetic and other productivity improvements must be seen in the context of improved agro-ecological, socio-economic and gender-sensitive approaches.
10. *Challenges to the CGIAR*: The CGIAR must seek to invest in and mobilize the necessary human, financial, and biological resources to address the production, policy, and sustainability challenges. This will require the CGIAR to: (i) Identify the researchable constraints; (ii) Invest more and with a greater sense of urgency in science to solve problems, integrating the new understanding of agroecological issues with the new opportunities in genetics and biotechnology; (iii) Build on traditional strengths in breeding, biology, genetic resources, and information management; (iv) Analyze, interpret, and make more accessible the wealth of biological data; (v) Access new skills to achieve new goals; (vi) Form purposeful strategic and project-specific alliances; (vii) Create more flexible and innovative implementation arrangements that cut across traditional Center and institutional boundaries; and (viii) Provide financial incentives for innovation and reward success."

"Prometheus changed the world forever when he unleashed the forces of innovation and creativity. In considering the applications of new developments in science, the challenge is to find ways to maximize the benefits, while also seeking to understand and minimize the risks."

"The economic concentration of investment, science, and infrastructure in industrial countries and the lack of access to the resulting technologies are major impediments to the successful applications of modern biotechnology to the needs of global food security and to create wealth for the presently poor people and countries. Creativity in finding solutions to these policy and institutional impediments to innovation are as important and challenging as new scientific discoveries, if the promises of Promethean science are to be realized."

International Service for the Acquisition of Agribiotech Applications (ISAAA)

Website: www.isaaa.org

"ISAAA is a not-for-profit international organization that shares the benefits of crop biotechnology to various stakeholders, particularly resource-poor farmers in developing countries, through knowledge sharing initiatives and the transfer and delivery of proprietary biotechnology applications. ISAAA's global knowledge sharing network and public and private sector partnerships in the research and development continuum provide a powerful combination of science-based information and appropriate technology to those who need to make informed decisions about their acceptance and use. In addition, an array of support services completes the holistic approach to agricultural development and ensures effective implementation and timely delivery of crop biotechnologies. These services include capacity building for policy makers and scientists; regulatory oversight on such issues as biosafety and food safety; and impact assessment."

World Bank. 2011. ICT in Agriculture: Connecting Smallholders to Knowledge, Networks and Institutions. An e-Sourcebook. Washington, DC: World Bank.

http://www.ictinagriculture.org/ictinag/sites/ictinagriculture.org/files/final_book_ict_agriculture.pdf

"Realizing the profound potential of information and communication technologies in developing country agriculture, the Agriculture and Rural Development Department (ARD) of the World Bank in collaboration with *info*Dev (part of the World Bank Group) embarked in an effort to explore and capture the expanding knowledge and use of ICT tools in agrarian livelihoods. In November 2011, the World Bank released an electronic Sourcebook (e-Sourcebook) to initiate further (and better) investment in this sector. Called "ICT in Agriculture", the e-Sourcebook provides practitioners within and outside of the World Bank Group with lessons learned, guiding principles, and hundreds of examples and case studies on applying information and communication technologies in poor agriculture."

This sourcebook was designed to support practitioners, decision-makers, and development partners who work at the intersection of ICT and agriculture. It aims to be a practical guide in understanding current trends, implementing appropriate interventions, and evaluating the impact of those programs. It combines cutting-edge expertise in ICT with empirical knowledge of a wide range of agricultural sectors, from governance to supply chain management. As an online knowledge source, it will continue to evolve and be updated to reflect the emerging and changing challenges and opportunities facing the sector.

Each module in the sourcebook discusses the key challenges, enablers, and lessons related to using ICTs in a specific subsector of agriculture. These are derived from a range of experiences, and summarize the knowledge gained during pilot projects and wider initiatives. While different in type of intervention and approach, a string of themes emerges from the modules. These themes—namely the why and how of using ICT in agricultural development—demonstrate the great potential of ICT and help to clarify the way forward.

Five main trends have been the key drivers of the use of ICT in agriculture, particularly for poor producers:

1. Low-cost and pervasive connectivity;
2. Adaptable and more affordable tools;
3. Advances in data storage and exchange;
4. Innovative business models and partnerships; and
5. The democratization of information, including the open access movement and social media.

These drivers are expected to continue shaping the prospects for using ICT effectively in developing-country agriculture.

A number of key lessons related to ICT-in-agriculture policies and projects were gleaned during the research for this e-Sourcebook. Using ICT to achieve agricultural development goals requires supplementary investments, resources, and strategies. Flexible but strongly supportive policies and regulations, complementary investments in physical infrastructure, support to men and women farmers of different age groups, technological appropriateness, and the enabling environments for innovation and new businesses will determine the long-term impact and sustainability of these efforts. These lessons are not conclusive—much remains to be learned—but they serve as sound considerations as investments are made in future interventions.

The sourcebook is supported by a dedicated website: http://www.ictinagriculture.org/.

ICT Update

http://ictupdate.cta.int/

ICT Update, initiated by CTA in 2001, is a bimonthly printed bulletin and web magazine. Each issue of ICT Update focuses on a specific theme relevant to ICTs for agricultural and rural development in African, Caribbean and Pacific (ACP) countries, and features a selection of commissioned articles.

Joseph, T. and M. Morrison. 2006. *Nanotechnology in Agriculture and Food*. A NanoForum Report.

http://www.nanoforum.org/dateien/temp/nanotechnology%20in%20agriculture%20and%20food.pdf

Many developed countries have identified the potential of nanotechnology in the agro-food sector and have prioritized it for investment. However, R&D into nanotechnology is not just restricted to developed countries only. Also developing countries such as Brazil, India, and Iran are investing in nanotechnology research targeting the agro-food sector. This paper provides an overview of existing as well as in-the-pipeline nanotechnology applications in the agro-food sector that are relevant to developing countries.

The report also discusses concerns over the use of nanoparticles in food and its manipulation using nanotechnologies. It highlights that there is the potential risk that nanotechnology will elicit the same issues as raised in the biotechnology debate.

FAO. 2010. International Conference on Food and Agriculture Applications of Nanotechnologies: Report of Technical Round Table Sessions. São Pedro, Brazil: FAO.

ftp://ftp.fao.org/ag/agn/agns/NANOAGRI_2010.pdf

"A number of emerging nanotechnologies could potentially provide significant benefits in various sectors, including food, water and agriculture. New and emerging applications such as water purification systems, rapid pathogen and chemical contaminant detection systems, and nano-enabled renewable energy technologies applied along the food chain may be the new tools to address some of the challenges pertaining to sustainable agricultural development as well as food safety and food security that countries are facing today – in particular developing countries.

Research and development in nanoscience and nanotechnologies have been growing in the public and private sectors in both developed and developing countries. It is becoming clear that in order to achieve the expected goals promised by nanotechnologies, the world community must ensure that direct, forthright global governance of these technologies is addressed.

In the light of these developments, the Government of Brazil, in collaboration with FAO, organized an international conference as a forum on new and emerging applications of nanotechnologies in food, water and agriculture. The purpose of the conference was to facilitate among stakeholder groups an exchange of

views and collaboration in promoting progress in areas that are of particular interest to developing countries."

Gruère, G., C. Narrod and L. Abbott. 2011. *Agricultural, Food, and Water Nanotechnologies for the Poor: Opportunities and Constraints.* IFPRI Policy Brief No.19. Washington, DC: IFPRI.

http://www.ifpri.org/sites/default/files/publications/bp019.pdf

"There are a number of potential opportunities associated with agricultural, food, and water nanotechnology for the poor, but to achieve such opportunities a number of challenges need to be overcome. This paper first provides a rapid assessment of key technologies that could have a large impact on the poor via increased agricultural productivity, improved food and water safety, and nutrition. Second, it reviews some of the main challenges to their deployment and adoption by the poor. It concludes with a discussion of the potential role of the CGIAR in facilitating the poor's access to beneficial nanotechnologies."

National Research Council (NRC). 2012. *Toward Sustainable Agricultural Systems in the 21st Century*. Washington, DC: National Academic Press.

https://download.nap.edu/catalog.php?record_id=12832

"In the last 20 years, there has been a remarkable emergence of innovations and technological advances that are generating promising changes and opportunities for sustainable agriculture, yet at the same time the agricultural sector worldwide faces numerous daunting challenges. Not only is the agricultural sector expected to produce adequate food, fiber, and feed, and contribute to biofuels to meet the needs of a rising global population, it is expected to do so under increasingly scarce natural resources and climate change. Growing awareness of the unintended impacts associated with some agricultural production practices has led to heightened societal expectations for improved environmental, community, labor, and animal welfare standards in agriculture.

Toward Sustainable Agricultural Systems in the 21st Century assesses the scientific evidence for the strengths and weaknesses of different production, marketing, and policy approaches for improving and reducing the costs and unintended consequences of agricultural production. It discusses the principles underlying farming systems and practices that could improve the sustainability. It also explores how those lessons learned could be applied to agriculture in different regional and international settings, with an emphasis on sub-Saharan Africa. By focusing on a systems approach to improving the sustainability of U.S. agriculture, this book can have a profound impact on the development and implementation of sustainable farming systems. *Toward Sustainable Agricultural Systems in the 21st Century* serves as a valuable resource for policy makers, farmers, experts in food production and agribusiness, and federal regulatory agencies."

One of the key recommendations of this report is that: "Federal and state agricultural R&D programs should aggressively fund and pursue integrated research and extension on farming systems that focus on interactions among productivity, environmental, economic, and social sustainability outcomes. Research should explore the properties of agroecosystems and the interdependencies between biophysical and socioeconomic aspects of farming systems, and how these interdependencies could make the systems robust and resilient over time."

"When considering the relevance of lessons learned in the United States to sub-Saharan Africa, it is important to recognize key differences between the two regions. Nonetheless, the concepts of sustainability and many of the broad approaches presented in this report are relevant and concur with conclusions from some recent international reports and they are summarized below.

- Use of a systems approach with an interdisciplinary focus and understanding is essential, as is an awareness of the social, economic, and policy context within which farming systems operate.
- Technologies to address soil, water, and biotic constraints are needed that integrate ecological processes and use locally available resources in combination with judicious use of external inputs when necessary.
- Promising technological approaches include improving soil quality by organic matter management and reduced tillage; integrated fertility management; water harvesting and use of drip irrigation; development of crop varieties that are resistant to environmental stress, diseases, and pests; development of improved animal breeds; greater integration of crops and animal production; and use of GIS to enable landscape and regional analysis and planning. Adoption of such technologies could be affected by multiple factors, including access to credit, that would have to be addressed to use available technologies.
- Investment in agricultural R&D needs to increase, and the new commitment by African nations to respond to this need presents a critical opportunity to create a research and extension system that reflects an interdisciplinary systems approach to addressing agricultural problems.
- New research programs would need to actively seek input and collaboration from farmers to ensure that appropriate research questions are being asked and technologies tested. Women play a critical role in African agriculture, and they need to be provided with educational and training opportunities and be involved in the development of research agendas.
- Expansion of access to markets will be essential to increase productivity and enhance livelihoods in rural Africa. Investing in rural infrastructure could improve local, regional, and international market access.
- The indigenous research and education system needs to be greatly strengthened, with institutions firmly grounded in interdisciplinary systems thinking and connected to local farmers and their production and livelihood needs."

Challenges

Kerr, J. and S. Kolavalli. 1999. Impact of Agricultural Research on Poverty Alleviation: Conceptual Framework with Illustrations from the Literature. EPTD Discussion Paper No.56. Washington, DC: IFPRI.

http://impact.cgiar.org/sites/default/files/KerrKolavalli1999.pdf

"This paper reviews the literature on the subject of the role of improved agricultural technology in alleviating poverty in developing countries. Focusing primarily on improved cultivars produced by the international agricultural research system, it shows how new technology combines with other socioeconomic and institutional factors to determine poverty alleviation outcomes. Technology's role in alleviating poverty is both indirect and partial; technology alone cannot overcome poverty, nor can continued poverty be blamed on improved technology. The review is organized into three parts in addition to the introduction and conclusion.

Part I introduces poverty (Chapter 2) and the achievements of agricultural research (Chapter 3). [..]

Part II provides a conceptual framework (chapter 4) and evidence from the literature (chapters 5-8) for the link between new agricultural technology and poverty alleviation. It takes a historical perspective, examining evidence from the literature. The discussion simplifies the complexity of the relationship between technological change and poverty alleviation by breaking it into four types of linkages: i) distribution of benefits across farms with different resource (particularly land) endowments, ii) distribution between farmers and laborers, iii) effects on food availability and consumption, and iv) impact on broader economic growth and employment. It is important to remember that many if not most

rural households in developing countries are simultaneously sellers and buyers of food and labor, so changes in agricultural prices have competing effects on their overall incomes. For such households these linkages must be examined jointly. [..]

Part III looks ahead to the future. It examines potential opportunities to focus agricultural research specifically on the needs of poor people. Chapter 9 discusses the prospects for designing technical characteristics of new technology in a way that would favor poor people. This could be done by developing seeds with favorable nutrition features, working on crops that poor people typically consume, or working in areas with a large population of poor people. Two schools of thought are sharply divided on this issue. One argues that targeting research objectives to specific poverty-alleviation objectives would have a high opportunity cost in terms of foregone productivity increases, which are critical to poverty alleviation for reasons explained in Part II. The other school of thought points out that many other poverty alleviation measures, such as various development projects and food supplementation efforts, have had poor performance at a very high cost, so it may well be that targeted agricultural research could be more cost-effective. Chapter 10 introduces participatory research and the possibility that poor people could have a greater say in the research agenda and the research process. Participatory research may facilitate improved performance in developing new technology for complex agricultural systems in unfavorable agroclimatic zones, which often have a high concentration of poor people. To date there has been little evaluation of the performance of participatory research, but it is an emerging area and the literature about it is growing. Chapter 11 discusses the possible implications on poverty alleviation of two recent developments in agricultural technology, biotechnology and precision agriculture. Unlike the green revolution, which was sponsored and executed by the nonprofit and public sectors, biotechnology is controlled by profit-making companies in developed countries. They focus on the scientific needs of highly commercialized agriculture, where farmers can afford to pay top dollar for new technologies. Biotechnology probably has great potential to help solve the problems facing poor farmers in developing countries, but to date there has been relatively little work in this regard. The Rockefeller Foundation's major program on rice biotechnology in Asia is a notable, welcome exception. Harnessing the potential of biotechnology to solve developing countries' needs, particularly in unfavorable, less commercialized areas, will require innovative collaborative efforts between developing country agricultural research systems and the private companies that dominate biotechnology. Chapter 12 focuses on research to assess the impact of agricultural research on poverty alleviation. Such evaluation efforts must overcome measurement difficulties associated with the fact that the relationship is indirect, with numerous confounding factors. Ideally the analyst would have data on conditions both before-and-after and with-and-without the introduction of new technology. This helps ensure that changes in poverty conditions are properly attributed to all of the actual determinants, including technology change but also other factors. There is also scope for introducing quasi experimental design to control for confounding factors. This has long been used in nutrition studies but is only just emerging in economic analysis. Research to assess the impact of agricultural research on poverty alleviation can be particularly effective by combining quantitative and qualitative research methods. Quantitative approaches are needed to analyze complex, indirect relationships regarding poverty reduction, while qualitative approaches can help understand poverty from local people's point of view, capturing important relationships that outsiders might overlook."

Hazell, P. and L. Haddad. 2001. *Agricultural Research and Poverty Reduction*. Food, Agriculture, and the Environment Discussion Paper no. 34. Washington, DC: IFPRI and TAC/CGIAR.

http://ageconsearch.umn.edu/bitstream/16233/1/dp010034.pdf

"Based on an analysis of the links between agricultural research and poverty alleviation in different types of countries and rural regions, the authors identify six key priorities for a pro-poor agricultural research agenda: (1) increasing production of staple foods in countries where food price effects are still important and/or that have a comparative advantage in growing these crops; (2) increasing agricultural productivity

in many less-favored lands, especially heavily populated low-potential areas; (3) helping smallholder farms across the board diversify into higher value products, including livestock products, especially in countries with rapidly growing domestic markets for such products and/or access to suitable export markets; (4) increasing employment and income-earning opportunities for landless and near-landless workers in labor surplus regions; (5) developing more nutritious and safer foods to enhance the diets of poor people; and (6) undertaking agricultural research in ways that are more empowering to the poor.

The authors discuss strategies for achieving each of these goals with the least trade-off in national agricultural growth. In short, they suggest strategies to target agricultural research on poor peoples' problems in ways that are "win-win" for growth and poverty reduction."

de Janvry, A. and E. Sadoulet. 2002. "World Poverty and the Role of Agricultural Technology: Direct and Indirect Effects". *Journal of Development Studies* Vol. 38: 1-26.

"Agricultural technology can help reduce poverty through direct and indirect effects. Direct effects are gains for the adopters while indirect effects are gains derived from adoption by others leading to lower food prices, employment creation, and growth linkage effects. Conceptualizing and measuring these effects is highly complex, yet is needed for each region if technology is to be used as an effective instrument for poverty reduction. We propose a methodology for doing this in the context of computable general equilibrium modeling and apply it to archetype models for Africa, Asia, and Latin America. Results show that the dominant effect of technology on poverty is through direct effects in Africa, indirect agricultural employment effects in Asia, and linkage effects through the rest of the economy in Latin America. In each case, increasing the poverty reduction effect through the targeting of technology across crops and through complementary rural development programs is also explored."

Hazell, P.B.R. 2008. The Impact of the Green Revolution in South Asia since the Green Revolution. Rome, Italy: Science Council Secretariat.

http://www.sciencecouncil.cgiar.org/fileadmin/templates/ispc/documents/Publications/1b-Publications_Reports_briefs_SPIA/SC_IA_south_asia_GreenRev.pdf

This study critically reviews and assesses the large body of evidence on the impacts of agricultural research by the CGIAR and its partners in South Asia. The long history of research, the extensive databases available and the vast literature on impacts that exist in this region provide a fertile ground for this study, which aims to systematically examine and understand the complexities of how research has led to outputs, uptake, outcomes and impacts, and the distributional consequences of these.

The study describes the evolution of priorities for agricultural R&D in South Asia from the time of the GR when 'food first' was the imperative and productivity growth in food staples in favored areas was established as the primary goal. This led to a subsequent focus in the 1980s on second-generation priorities such as natural resources management (NRM), the off-site externalities that arose from the intensification associated with the GR, increasing the productivity and quality of high-value crops, trees and livestock, agricultural intensification in many less-favored areas (including food grain crops), more precise targeting of the problems of the poor (including enhancing the micronutrient content of food staples), and analysis of policy and institutional options for achieving more sustainable and pro-poor outcomes in the rural sector. The available evidence presented in this report suggests that the national public R&D systems and the CGIAR have responded well to these changing needs, both in terms of their budgetary allocations and the kinds of research they have undertaken.

However, with the current dramatic cereal price increases and disturbingly low global food grain stocks leading to another food crisis, one wonders whether we might not be facing a 'back to the future'

situation, where the priority once again should be to sustainable food grain productivity improvement in the more-favored South Asian ecosystems.

This is obviously a key strategic question both for the CGIAR and its NARS partners in the region. With the growing numbers and share of urban poor expected in future, there is also a question as to the appropriate future emphasis in R&D strategies on poor smallholder/subsistence farmers with small or no marketable surpluses of food grains, versus those farmers with larger marketable surpluses that can exert a more powerful influence on food grain prices, which are so critical to the welfare of the urban poor and poor net buyers of food grains in rural areas.

The author's analysis of alternative paradigms to the GR approach such as organic farming and low-input sustainable agriculture (LISA) favored by the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD),[18] indicate that these do not seem to be viable in the favored areas where the GR had its major impact, but may offer more promise in less-favored areas. The conclusion one can draw from this is that it is unlikely that shifting to such alternative paradigms at this critical juncture as an alternative to the GR approach, as preferred by the IAASTD, would successfully address the current food crisis.

The author points out that today agriculture in South Asia is not so significant in the livelihoods of the poor as it was in the GR era. Rural nonfarm revenue is a much more important source of income than previously. This means that agricultural productivity increases from R&D cannot be expected to have the same impact on growth and poverty alleviation as in the 1960s and 1970s, even though it still remains the most attractive win-win public investment opportunity in the region. There is some evidence of this in the declining poverty reduction impacts of rice research investments over the time since the GR era from one study cited by Hazell. While poverty reductions are currently cost-effectively achieved by rice research investments, the cost of raising each person out of poverty is increasing.

The main findings of this study are generally consistent with what is widely known or believed about the GR and post-GR developments, i.e., that agricultural research has continued to provide essential outputs that have helped maintain productivity growth in agriculture, continues to generate high economic rates of return on investments and, indirectly, through the price effects, has contributed to food security and poverty alleviation, both rural and urban. While a number of empirical studies demonstrate the link between agricultural research investments and productivity outcomes, there are few empirical studies that link agricultural research investments to poverty and environmental outcomes. As Hazell points out, apart from needing these kinds of studies to assess the economic value of poverty and environmentally oriented research, they are also needed to better understand the potential tradeoffs and/or complementarities between attainment of productivity, social, and environmental goals in agricultural research and for determining the kinds of research that offer the best prospects of win-win-win outcomes. While assertions abound about the negative environmental impacts of productivity-enhancing agricultural developments, there are actually few empirical studies that have documented or quantified this effect. Indeed, it is likely that much of the productivity-enhancing research has had positive (but unmeasured) effects in terms of saving millions of hectares of forested land from coming under crop cultivation.

As there are very few impact studies from South Asia that estimate returns to research investments corrected for environmental costs and benefits, or that calculate the research investment cost associated with an observed reduction in the number of poor, the study emphasizes the need to develop a set of environmental and poverty indicators that can be used in comprehensive impact assessments; a broader range of indicators, not all of which need to be quantitative, is required.

[18] See section 6.3.

The study indicates the need for a holistic household approach to the assessment of the impacts of agricultural research on poverty, due to its complexity. There are winners and losers from research, both among households within a village and even among members within a household, as well as between rural and urban dwellers and favored versus less-favored areas. These impacts are also both direct and indirect.

Alcadi, R., S. Mathur and P. Rémy. 2009. *Research and Innovation for Smallholder Farmers in the Context of Climate Change*. Discussion paper prepared for the Round Table organized during the Thirty-second session of IFAD's Governing Council, 18 February 2009. Rome: IFAD.

http://www.ifad.org/events/gc/32/roundtables/3.pdf

"Agricultural producers, in particular the smallholder farmers of developing countries, are facing unprecedented challenges in the 21st century. With an estimated 9.2 billion people to feed by 2050 – of whom 8 billion will be in developing countries – and increasing scarcity of land and water, productivity gains will have to be the main source of growth in agriculture and the primary means to satisfy increasing demand for food and other agricultural products. With globalization and new supply chains, farmers will need to continuously innovate to respond to changing market demands and remain competitive.

Moreover, "climate change has the potential to irreversibly damage the natural resource base on which agriculture depends." All regions of the world, and especially the diverse and vulnerable rainfed systems of sub-Saharan Africa, need technologies, knowledge and practices that simultaneously increase their productivity, their resilience to climate change and their contribution to its mitigation.

Climate change is increasing production risks in many farming systems and reducing the ability of farmers and rural communities to manage these risks on their own. Around the world, resource-poor farmers and pastoralists are trying to adapt to the effects of climate change, which affect them disproportionately: (i) dwindling crop yields; (ii) desertification and land degradation processes, exacerbated by changes in rainfall patterns; (iii) rising sea levels, affecting in particular the livelihoods of coastal communities; (iv) diminishing natural resource productivity; and (v) in some areas, irreversible loss of biodiversity.

For example, in sub-Saharan Africa, it is projected that an additional 17-50 million people could be undernourished in the second half of the century because of climate change. Extreme wind and turbulence could decrease fish productivity by 50-60 per cent in countries like Angola, Congo, Côte d'Ivoire, Mali, Mauritania, Niger, Senegal and Sierra Leone. Projected sea-level rise along the eastern and western coasts of the continent will cause coastal agriculture, a major source of livelihoods for smallholders in Benin, Côte d'Ivoire and Ghana, to be at risk of inundation, soil erosion and salinization.

The agricultural sector offers opportunities for mitigating climate change. Agriculture has strong potential to reduce greenhouse gas (GHG) emissions by promoting clean and efficient energy, reducing deforestation and promoting sustainable agricultural practices such as the rehabilitation of degraded lands, water conservation and management, and increased biomass production. Since rural people manage vast areas of land and forest, they are important players in natural resource management and carbon sequestration.

However, they are not usually compensated for their efforts in any significant way. In the second half of the last century, agricultural research played a major role in rapidly increasing agricultural production and reducing rural poverty in Asia. But after 20 years of disengagement, progress in productivity gains has slowed, environmental damage has increased, global warming has accelerated and the number of hungry people is on the rise. All of these situations call for reinvesting in agricultural knowledge, science and technology for achieving equitable and sustainable development.

The purpose of this paper is to discuss: (i) the potential role of agricultural research in improving small farmers' productivity and ability to adapt to and mitigate climate change; and (ii) how to increase investments in international research and sharpen its focus on the challenges faced by regions that are most vulnerable to climate change."

Chapter 4: Re-energizing investment in research that is impact oriented

Investment patterns in agricultural research

Pardey, P.G. and J. Roseboom. 1989. *ISNAR Agricultural Research Indicator Series*. Cambridge: Cambridge University Press.

Landmark statistical publication covering time series data (1961-85) for NARS-level agricultural research expenditures and researchers. Incorporated earlier data compilations by Evenson and Kislev[19] and Oram and Bindlish,[20] the 1984 ISNAR Survey of NARS, as well as a large volume of secondary sources. Every data entry was carefully documented. The tables were accompanied with a short description of the NARS and the data coverage. The ASTI Initiative (see below) is a continuation of this effort.

Pardey, P.G., J. Roseboom and J.R. Anderson, eds. 1991. *Agricultural Research Policy: International Quantitative Perspectives*. Cambridge: Cambridge University Press.

Part three of this book provides global and regional overviews of NARS investments as well as a series of analyses of topical issues such as sources of funding. Based on agricultural research expenditure and staffing data compiled by the ISNAR Indicator Series publication (see the immediately above), a meta-dataset was constructed in order to allow for analysis of trends over time and across countries and regions.

In a meta-dataset, missing data are estimated using interpolation and extrapolation techniques as well as correlation techniques. For example, if data for a country are not available one can (usually as a last resort solution) insert the regional or same income-group average research intensity as an estimate for that country. One has to be careful not to push this technique too far [e.g., imposing it on big countries] -- otherwise it can lead to spurious results. It is for that reason, for example, that no estimates were made for the Soviet Union and Eastern European countries at that time.[21]

By introducing this meta-dataset (covering 115 developing countries and 22 developed countries), this publication set the standard for future global overviews of agricultural research investment and presented a series of stylized indicators, such as global and regional estimates of agricultural research expenditures and agricultural researchers from 1961-65 to 1981-85, expenditure and staff growth rates, various research intensities, and expenditures per researcher.

A different approach was used in the topical issues chapter (chapter 8). Rather than trying to construct a meta-dataset, only the agricultural research agencies for which there were detailed data were included in the analysis. The underlying assumption is that the sample of agencies for which there are data is

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[19] Evenson, R.E. and Y. Kislev. 1971. *Investments in Agricultural Research and Extension: A Survey of International Data*. Discussion Paper No. 124. New Haven, Connecticut: Economic Growth Center, Yale University.

[20] Oram, P. and V. Bindlish. 1981. *Resource Allocations to National Agricultural Research: Trends in the 1970s.* The Hague and Washington, DC: ISNAR and IFPRI.

[21] Jock Anderson was one of the first to take a stab at this for a lecture at Purdue in 1997 and in a piece with Carl Pray: Pray, C.E. and J.R. Anderson. 1997. "The agricultural research system of the Former Soviet Union: Past and future", *Journal of International Development* 9(4), 517-27.]

representative for the whole population of agricultural research agencies. Depending on the topic, the sample size differed. Moreover, the topical approach did not aim to monitor changes over time. It simply pooled data observations for the period 1981-85.

Topical issues that were addressed included:

1. Institutional composition of NARS – generally a low share of universities, but rising;
2. Research orientation –68.3% crops, 18.7% livestock, 7.3% forestry, and 5.7% fisheries;
3. Breakdown of the research budget per cost category: 57% salaries, 25% operating costs, and 19% capital costs.
4. Qualification profile of research staff. In the early 1980s, expatriates still played an important role in many NARS and in particular in SSA (some 29% of the research staff). Less than one-half of the national researchers held an MSc or higher degree.
5. Dependence on donor funding. High in SSA and Asia (excl. China) – on average 35% (SSA) and 26% (Asia), but with wide variations.

The book also includes separate chapters for agricultural research investments by the IARCs and by the private sector. Subsequent related efforts include:

Alston, J.M., P.G. Pardey and J. Roseboom. 1998. "Financing Agricultural Research: International Investment Patterns and Policy Perspectives." ***World Development*** **Vol. 26, No 6 (pp. 1057-1072).**

Alston, J.M., P.G. Pardey and V.H. Smith, eds. 1999. ***Paying for Agricultural Productivity*****. Baltimore: John Hopkins University Press.**

Both publications include an update of the meta-dataset for NARS expenditures up to 1991. Country coverage improved from 137 to 151 and all expenditure data were re-based to 1985 PPP dollars.

Pardey, P.G. and N.M. Beintema. 2001. ***Slow Magic: Agricultural R&D a Century after Mendel*****. Washington, DC: IFPRI.**

http://www.ifpri.org/sites/default/files/publications/fpr31.pdf

This publication presents an update of the meta-dataset for NARS expenditures up to 1995. The number of countries covered increased to 153 and all expenditure data were re-based to 1993 PPP dollars. Global NARS expenditures were estimated at $ 21.7 billion (1993 PPP dollars) in 1995. Growth in NARS expenditures slowed down from an average 3% per annum during 1986-91, to 2% during 1991-96. Growth in agricultural research expenditures slowed down in particular in developed countries and in SSA. In the latter region, NARS expenditures actually declined in real terms in the early 1990s. On the other hand, growth in NARS expenditures in China and LAC accelerated. Between 1976 and 1995, the share of developed countries in total NARS expenditures declined from 60% in 1976 to 47% in 1995.

Another way to group countries is by tropical versus non-tropical. In 1995, 72% of the NARS expenditures took place in non-tropical countries and only 28% in tropical countries. Nevertheless, this was an improvement upon the situation in 1976 when only 21% of the global NARS expenditures took place in tropical countries.

The share of universities and non-profit research agencies in NARS is considerably higher in developed countries than in developing countries. Nevertheless, a slow trend towards more institutional diversity can be noted across developing-country NARSs.

Donor funding (including World Bank lending) of NARS sharply contracted in the early 1990s. To a large extent this explains the noted contraction of NARS expenditure in SSA.

Matching private investments in agricultural research (including agricultural input industries, primary agricultural production as well as food processing industries) yielded some $ 11.5 billion (1993 PPP dollars) in 1995. Most of this private investment (94%) was concentrated in developed countries.

Pardey, P.G., J. M. Alston and R. R. Piggott, eds. 2006. *Agricultural R&D in the Developing World: Too Little, Too Late?* Washington, DC: IFPRI.

http://www.ifpri.org/sites/default/files/pubs/pubs/books/oc51/oc51.pdf

This book was conceived as a companion to the 1999 volume Paying for Agricultural Productivity (see above), which dealt with investments, institutions, and policy processes regarding agricultural R&D in developed countries. This book addresses the same set of issues for the developing countries, and the relationship of those countries to the richer parts of the world where the preponderance of agricultural innovation still takes place. The core of the book centers around nine case studies of NARS in the developing world.

"The book combines new evidence with economic theory and an economic way of thinking about science policy—highlighting the developing-country aspects— as well as a set of in-depth, comparative country studies. These country studies take us well beyond generalities, providing insights into the important changes taking place within these countries and others they represent. The countries covered include the largest developing countries—China and India—as well as a range of richer and poorer, and more- and less-developed countries, representing most parts of the globe.

The evidence and ideas presented in the book are disquieting. Over the past several decades, at least, spillovers of agricultural technology from rich countries to poor countries demonstrably increased productivity and food security for many parts of the developing world. As the authors document, however, recent developments in both the developed and developing worlds mean that poor countries may no longer be able to depend as they have in the past on spillovers of new agricultural technologies and knowledge from richer countries, especially advances related to enhanced productivity of staple foods.

As a consequence of these changes, simply maintaining their current agricultural R&D policies may leave many developing countries as agricultural technology orphans in the decades ahead. Developing countries may have to become more self-reliant and perhaps more dependent on one another for the collective benefits of agricultural R&D and technology. Some of the more advanced developing countries like South Korea, Brazil, China, and India seem to be gaining ground, with productive and self-sustaining local research sectors taking hold. However, other parts of the developing world, as illustrated in this book by reviews of agricultural R&D in Zambia, Bangladesh, and Indonesia, are merely regaining lost ground or slipping further behind. Aside from a handful of larger countries, many developing countries, especially in Africa, are facing serious funding and institutional constraints that inhibit the effectiveness of local R&D. Together, these factors may lead to serious food deficits.

The information assembled here and the lessons learned in this volume argue for refocusing attention on agricultural R&D as an instrument for long-run economic development to help avert a continuation of the chronic hunger and malnutrition that afflict all too many people around the world. These lessons will pay off if they help revitalize multinational engagement and investment in the global public benefits of international agricultural research."

Spielman, D.J. and R. Birner. 2008. *How Innovative is Your Agriculture? Using Innovation Indicators and Benchmarks to Strengthen National Agricultural Innovation Systems*. Agricultural and Rural Development Discussion Paper No. 41. Washington, DC: World Bank.

http://siteresources.worldbank.org/INTARD/Resources/InnovationIndicatorsWeb.pdf

This publication reflects the shift in the analytical framework from NARS, to AKIS, to AIS. It proposes the development of composite agricultural innovation indicators that capture the complexity of the agricultural innovation process.

"[…] as agricultural innovation becomes increasingly viewed as a complex process that defies simple solutions, it has become more and more difficult to identify the types of investment and policy interventions needed to make developing-country agriculture more responsive, dynamic, and competitive."

"The "national system of innovation" framework offers an interesting perspective for guiding investment and policy interventions in this area. The framework draws attention to the wide range of actors and organizations from the public, private and civil society sectors that are involved in bringing new products, processes and forms of organization into economic use. The framework also emphasizes the role of the institutional and policy environment that affects their performance and behavior."

"This paper explores the application of the innovation systems framework to the design and construction of national agricultural innovation indicators. Optimally, these indicators could be used to gauge and benchmark national performance in developing more responsive, dynamic, and innovative agricultural sectors in developing countries."

Stads, G.J. and N.M. Beintema. 2009. *Public Agricultural Research in Latin America and the Caribbean: Investment and Capacity Trends.* Washington, DC: IFPRI and IDB.

http://www.asti.cgiar.org/pdf/LAC_Syn_Report.pdf

"In 2006, LAC as a whole employed more than 19,000 FTE researchers in agriculture and invested $3.0 billion in agricultural R&D (in 2005 constant prices), which corresponds to 1.14 percent of the region's total AgGDP. Nevertheless, 70 percent of this total was spent by just three countries: Argentina, Brazil, and Mexico. Were these "big three" countries excluded, the region's agricultural R&D investments as a percentage of AgGDP would be substantially lower (0.72 percent). Regionwide investments grew by 1.1 percent per year during 1981–2006, but this average masks significant differences over time and among countries. During 1996–2006, agricultural research spending in countries such as Argentina, Costa Rica, and Uruguay rose markedly, whereas expenditures in countries such as Chile, El Salvador, Guatemala, Honduras, and Paraguay contracted. Brazil, the region's largest country, also experienced a modest decline in its agricultural R&D investments since the mid-1990s largely due to reduced spending by the country's state government agencies in recent years."

LAC's human resource capacity in agricultural R&D shows similar diversity across countries. Argentina, Brazil, and Mexico each have large and comparatively complex systems employing thousands of scientists, whereas capacity in the countries of the Caribbean and Central American is understandably much smaller. Overall, entities conducting agricultural R&D in the LAC region have become increasingly diversified in recent decades, with the INIAs occupying a progressively lower share of total research staff numbers. Large national differences in the average qualifications of agricultural scientists are also present; nonetheless, qualification improved overall in most countries in the past decade. A worrying trend, however, is that the pool of scientists is aging and some countries have failed to address this with initiatives to train and hire younger scientists.

Most agricultural R&D in LAC is funded by national governments, but sources differ widely across countries. Commodity taxes on the sale of production or on exports have become popular in many countries, especially Colombia and Costa Rica, and competitive funding mechanisms are also gaining popularity in a large number of countries.

Donor dependency for the LAC region as a whole is much lower than in Sub-Saharan Africa, although it remains very high in countries such as Nicaragua and Honduras. [Internally generated resources from sales of produce, laboratory services, consultancies as well as research contracts with private companies often also constitute an important source of income for public agricultural research organizations in the region.]

Beintema and Pardey (2001) argued that the most worrying trend in agricultural R&D in LAC was the apparent bifurcation of agricultural research. More recent data to 2006 confirm that the gap between the region's low- and middle-income countries has in fact widened. Some of the poorer, agriculture-dependent countries—such as Guatemala, El Salvador, and Paraguay—experienced sharp cuts in their agricultural research expenditures and intensity ratios over the past decade, while some of the more economically advanced countries (such as Argentina and Mexico) experienced growth. It is becoming increasingly clear that the region's low-income countries are slipping behind in their ability to generate new technologies and varieties. Moreover, most of the region's poorest and technologically most challenged countries are in tropical zones, putting them at a disadvantage compared with their more advanced neighbors in temperate zones, which gain large benefits from the spillover of technologies and varieties generated in high-income countries with similar agroclimatic conditions. But for the small LAC countries active in exporting tropical fruits and vegetables the private sector is important in introducing improved cultivars and practices that underpin high-quality produce for export.

Sustainable financial support for agricultural R&D is crucial in all countries of the region, not only in support of revenue-generating export crops, but also in support of much-needed food crops and, more generally, development initiatives to alleviate rural poverty. If the region is to achieve food security, reduce poverty, and compete in an increasingly competitive global market, strong political support for agricultural R&D is called for in addition to financial support, as is greater integration of agricultural R&D systems both within and among countries."

Beintema, N. and G-J. Stads. 2011. *African Agricultural R&D in the New Millennium: Progress for Some, Challenges for Many.* Washington, DC: IFPRI.

http://www.ifpri.org/sites/default/files/publications/pr24.pdf

"After a decade of stagnation during the 1990s, investments and human resource capacity in public agricultural research and development (R&D) in Sub-Saharan Africa (SSA) started to pick up again during 2001–2008. In 2008, the region spent $1.7 billion on agricultural R&D (in 2005 purchasing power parity dollars)—or $0.8 billion (in 2005 constant US dollars)—and employed more than 12,000 full-time equivalent (FTE) agricultural researchers. Most of this growth, however, occurred in only a handful of countries and was largely the result of increased government commitments to augment incommensurately low salary levels and to rehabilitate neglected infrastructure, often after years of underinvestment. Many countries—particularly those in francophone West Africa, which are threatened by extremely fragile funding systems—face fundamental capacity and investment challenges. National investment levels in such countries have fallen so low as to leave them dangerously dependent on often volatile, external funding sources. Despite the overall growth in capacity recorded, average qualification levels have deteriorated in a number of countries. Some reported large influxes of BSc-qualified scientists, often in response to prolonged recruitment restrictions, further straining already inadequate training opportunities and far exceeding the capacity for appropriate oversight and mentorship by senior researchers, given years of nonreplacement of retiring and departing scientists.

Notwithstanding the challenges facing many countries, renewed commitment to agricultural R&D by governments and donors indicates improved prospects for agricultural R&D for a number of African countries. Regional initiatives are also a key factor in increasing research coordination and collaboration and ensuring the prioritization and efficiency of research. Increased and sustained investment from

national governments, regional and international organizations, and large donors will go a long way toward stabilizing investment and capacity levels and enabling real progress for agricultural R&D in the region.

Building on the strategic recommendations of various highly influential reports and meetings, and taking into account the various investment and capacity challenges outlined in this report, four key areas with strong implications for policy must be addressed by governments, donors, and other stakeholders: (1) decades of underinvestment in agricultural R&D; (2) excessive volatility in yearly investment levels; (3) existing and imminent challenges in human resource capacity; and (4) the need to maximize regional and subregional cooperation in agricultural R&D."

Stads, G-J. 2011. "Africa's Agricultural R&D Funding Rollercoaster: An Analysis of the Elements of Funding Volatility". Conference Working Paper No.2 prepared for the ASTI/IFPRI-FARA Conference Agricultural R&D: Investing in Africa's Future. Accra, Ghana, 5-7 December 2011.

http://www.asti.cgiar.org/pdf/conference/Theme1/Stads.pdf

"The inherent lag from the inception of research to the adoption of a new technology or the introduction of a new variety calls for sustained and stable research and development (R&D) funding. The time-series data presented in this paper, however, reveal that agricultural R&D funding in many Sub-Saharan African (SSA) countries has been far from stable. Agricultural R&D agencies in SSA, particularly those in the region's low-income countries, are very dependent on funding from donors and development banks, and this type of funding has shown considerably greater volatility over the past decade compared with government funding and other sources. Numerous examples show that agencies reverted into financial crisis upon the completion of large donor-funded projects, forcing them to cut research programs and lay off staff.

Volatility in year-to-year spending levels can be halted only with sustained, long-term backing from national governments, donors, regional and international organizations, as well as the private sector. Governments have to clearly identify their long-term national R&D priorities and design relevant, focused, and coherent R&D programs accordingly. Donor funding needs to be better aligned with national priorities, and consistency and complementarities between donor programs need to be ensured. Moreover, diversification of funding sources is needed, for example, through the sale of goods and services and increased participation in and funding of research by the private sector. This, in turn, requires that national governments provide a more enabling policy environment."

Stads, G-J. and M. Rahija. 2012. *Public Agricultural R&D in South Asia: Greater Government Commitment, Yet Underinvestment Persists*. Washington, DC: IFPRI.

http://www.asti.cgiar.org/pdf/ASTI-South-Asia-Regional-Synthesis.pdf

"This report analyzes input indicators of public agricultural R&D for five South Asian countries: Bangladesh, India, Nepal, Pakistan, and Sri Lanka. It presents trends and challenges with regard to agricultural R&D investments and human resource capacity throughout the subregion, and provides recommendations for ways to address some of these challenges.

The landscape of South Asian agricultural R&D is highly complex, comprising a large number of government, higher education, nonprofit, private sector, and international research agencies. The data presented in this report include only public national agricultural R&D. Staff and spending data for private-sector companies and international agricultural R&D agencies operating in the subregion, such as the centers of the Consultative Group on International Agricultural Research (CGIAR), have been excluded.

Over the past two decades, the institutional structure of public agricultural R&D in South Asia has remained largely unchanged. While there have been ongoing internal reorganizations, none of the countries has undertaken fundamental restructuring of its agricultural research system, as was common practice throughout the 1960 and 1970s (Beintema and Stads 2008). As of 2009, the study identified 167 public agencies conducting agricultural R&D in India, 123 in Pakistan, 54 in Bangladesh, 20 in Sri Lanka, and 8 in Nepal. Of these 372 public agencies in total, 236 were claasified as government agencies, 132 as higher education agencies, and 4 as nonprofit agencies. Despite differences in size and structure, the organization and coordination of national agricultural R&D systems bear some similarities across the five countries: all have national agricultural research councils that coordinate agricultural R&D, set priorities, and administer competitive grant schemes, although their roles and scope of authority vary and in some cases are undergoing change." The specifics relating to each country are discussed in the report.

"The institutional composition of public agricultural R&D in South Asia has remained relatively unchanged since the mid-1990s. As of 2009, government agencies represented about two-thirds of agricultural R&D capacity in the subregion, while the higher education sector accounted for roughly one-third, and the nonprofit sector for less than 1 percent . These subregional shares mask major cross-country differences. While the government sectors in Bangladesh, Nepal, Pakistan, and Sri Lanka employ the majority of these countries' agricultural researchers, in India the higher education sector dominates in terms of R&D staff numbers: in 2009, universities (mostly SAUs) accounted for 57 percent of Indian agricultural R&D capacity. Nepal is the only country in the subregion where the nonprofit sector plays a significant role in agricultural R&D, representing 9 percent of the country's agricultural research capacity in 2009.

Historically, agricultural R&D planning in South Asia has operated from the top down, and linkages between agricultural R&D agencies and extension or advisory services have generally been weak. Exceptions do exist where research is successfully embedded in development practice, but on the whole channels for distributing the outputs of public agricultural research to their end users remain poorly developed (Hall and Sulaiman 2008).

Nevertheless, the need to improve linkages between agricultural R&D agencies and other organizations is widely recognized across the subcontinent. India's National Agricultural Innovation Programme (NAIP) and Bangladesh's National Agricultural Technology Project (NATP) both have large components devoted to developing research consortia with civil society and private partners. Both programs aim to enhance R&D coordination at the national level and strengthen the coordinating role of the ARCs. The National Agricultural Research Fund (NARDF) in Nepal similarly encourages more diverse participation in research projects, while in Pakistan efforts are underway to strengthen PARC and improve its relevance and effectiveness under the government's new configurations and economic growth priorities."

"New quantitative evidence presented in this report demonstrates that total public agricultural R&D spending in South Asia more than doubled between 1996 and 2009, while the number of agricultural researchers decreased by 6 percent. These trends were largely driven by India, which has the highest investment levels and strongest human resource capacity in agricultural research South Asia by far (both in terms of size and qualification levels), as well as the highest agricultural research spending intensity at 0.4 percent of AgGDP. Other aspects that set India apart from its neighbors are the comparatively important role of its private sector in agricultural R&D and the sweeping NAIP–stimulated agricultural R&D reform process, which is exploring new forms of consortia-based partnerships involving farmers and private enterprises to increase the relevance and efficiency of research. Overall, Indian agricultural research is relatively well-funded, although the budgets of some state agricultural universities have fallen in recent years.

Compared with India, agricultural R&D in the four other South Asian countries faces greater challenges. Relative investment levels are lower in these countries than in India and have shown greater year-to-year

fluctuations, in many instances due to the instability of donor funding. Agricultural research staff in these countries is also significantly less-qualified than in India, the combined result of prolonged recruitment freezes, losses of highly qualified senior staff, limited training opportunities, and an aging population of researchers. In addition, political instability in some countries has either delayed or complicated muchneeded institutional and policy reforms. Some countries have been left with complex or outdated agricultural R&D structures that are unsuited to current needs. Various policy reforms have been or are in the process of being implemented to address some of these institutional inefficiencies, including the 18th Amendment to the Constitution in Pakistan (which devolved much of the oversight of the agriculture sector to the provinces); the Strategic Vision for Agricultural Research, 2011–30, in Nepal; NATP in Bangladesh, and NARP in Sri Lanka.

Despite rapid increases in recent years, South Asia's agricultural R&D spending is still very low compared with other developing regions around the world. Agricultural R&D intensity ratios in Pakistan (0.21) and Nepal (0.23) are among the lowest in the developing world, and even India (0.40) invests a considerably lower share of its agricultural output on agricultural R&D than other emerging economies such as China (0.50 in 2008) and Brazil (1.80 in 2006). These indicators are a clear sign that South Asia is underinvesting in agricultural research, which doesn't bode well for future generations.

The subregion's population is predicted to continue to grow sharply until 2050, which—together with additional challenges stemming from climate change and environmental degradation—will necessitate increased food production. Being aware of these challenges, the subregion's national governments have set ambitious, but seemingly unrealistic, agricultural R&D investment targets. Investment levels not only need to increase, but also be better managed, timed, and targeted to ensure maximum impact on productivity growth and poverty reduction, particularly in less-favored areas. Increased diversification of funding sources will also be necessary, for example, through increases in the sale of goods and services and in participation by the private sector, which in turn requires that national governments focus on providing the necessary enabling policy environment.

The scientific competence of South Asia's agricultural R&D agencies is high, particularly in India, but as in many developing regions of the world, stronger linkages are needed to connect agricultural research agencies and their staff with the end users of their research to improve the relevance, effectiveness, and efficiency of research outputs. Further efforts to strengthen subregional linkages are also needed in order to better utilize limited resources and reduce wasteful duplication. In addition, good governance is key to promoting the effectiveness and efficiency of research, and ongoing policy and institutional reform will be needed to further strengthen agricultural R&D and innovation in South Asia."

Beintema, N., G-J. Stads, K. Fuglie and Paul Heisey. October 2012. *ASTI Global Assessment of Agricultural R&D Spending: Developing Countries Accelerate Investment*. Washington, DC: IFPRI.

http://www.asti.cgiar.org/pdf/ASTI_global_assessment.pdf

This most recent ASTI publication presents an updated version of the meta-dataset for NARS expenditures for the period 1981-2008. The number of countries covered increased to 179 (mainly through the inclusion of the former Soviet states and other countries of Eastern Europe for the first time) and all expenditure data were re-based to 2005 PPP dollars. Estimated global NARS expenditures reached $31.7 billion (2005 PPP dollars) in 2008. Compared to the 1990s, growth in NARS expenditures in the 2000s accelerated in low- and middle-income countries (and in particular in the later years of that period), but slowed in high-income countries.

Geographically, growth in public agricultural research expenditures over the period 2000-2008 has been particularly high in Eastern Europe and the former Soviet Union (on average 8.6% per annum, but this

after a major collapse of investment during the 1990s when the communist system was dismantled) and in Asia & Pacific (5.8% per annum, driven largely by China).

Intensity ratio

"The average agricultural R&D intensity ratio (i.e., expenditures as a % of AgGDP) for the developing countries as a group—and for individual developing regions— has remained fairly constant over time at around 0.5%. In other words, growth in R&D spending roughly tracked growth in agricultural GDP in developing countries. In high-income countries, in contrast, the intensity ratio increased from 2.6% in 2000 to 3.1% in 2008, and prolonged the steady rise in the intensity ratio (in 1976 the intensity ratio for high-income countries stood at 1.5%). The higher intensity ratio for high-income countries reflects a number of factors:

1. As countries develop and their economies become more knowledge-based, R&D intensity ratios tend to rise in all segments of the economy and in both the public and private sectors.
2. Countries at or near the productivity frontier tend to emphasize basic science to advance the frontier, and maintenance research to sustain productivity at a high level.
3. Research agendas for public institutions tend to broaden as national income levels rise (reflecting changing preferences); as a result, greater emphasis is given to issues such as environmental protection, food safety, and rural well-being, whereas less emphasis is given to raising productivity. The latter issue is left more to the private sector.

Developing countries, on the other hand, focus more of their resources on applied research to facilitate closing yield or productivity gaps and adapting technologies to local conditions. Nevertheless, small developing countries are often observed to have higher research intensities based on their inability to take advantage of scale economies. To be effective, national research systems may need to establish some minimum capacities across all relevant disciplines and major commodities, regardless of the size of the agricultural sector the system is designed to serve. For example, while China and India have had lower research intensity ratios than many countries in Africa south of the Sahara, their research systems are better equipped to address farmers' scientific and technological challenges due to their larger absolute size and greater research capacities.

Due to their limitations, intensity ratios should be used neither as the sole measure of public agricultural R&D spending levels across countries nor as a target to be reached. The ratios do not take into account the policy and institutional environment within which agricultural research occurs, and they cannot account for the influx of foreign technologies. The interpretation of intensity ratios therefore requires consideration of a complex and fluctuating set of factors, including investment growth, human resource capacity, and infrastructure. Higher intensity ratios don't always reflect increased agricultural R&D spending; they can also reflect declining or stagnating agricultural output. For example, while the rapidly rising intensity ratio of high-income countries in recent years can be explained in part by increased R&D investment (0.8 percent per year from 2000–2008), falling agricultural GDP figures (of –1.4 percent per year) actually had an even larger impact."

ASTI website

http://www.asti.cgiar.org/

On the ASTI website a large number of developing country studies can be found providing detailed information on NARS investments as well as regional overview studies and topical papers.

Agricultural research impact assessment

Anon. (1985), *International Agricultural Research Centers: A Study of Achievements and Potential*. Summary of study directed by J.R. Anderson, CGIAR, Washington, DC, pp. 32.

http://library.cgiar.org/handle/10947/1337

A short downloadable summary of the large Impact Study, some 850 pages.

Alston, J.M., G. Norton and P.G. Pardey. 1995. *Science under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting*. Ithaca and London: Cornell University Press.

This publication is *the* standard reference book for calculating the economic impact of agricultural research. It describes and illustrates in detail the different methodological approaches and evaluates their relative strengths and weaknesses.

Alston, J.M., C. Chan-Kang, M.C. Marra, P.G. Pardey and T.J. Wyatt. 2000. *A Meta-Analysis of Rates of Return to Agricultural R&D*. IFPRI Research Report No. 113. Washington, DC: IFPRI.

http://www.ifpri.org/sites/default/files/pubs/pubs/abstract/113/rr113.pdf

Various compilations of agricultural research rate-of-return studies have been published over the years (e.g., by Bob Evenson and Ruben Echeverría), but this study is a landmark in the sense that it applies a meta-analysis to these studies and tried to answer questions such as:

1. Has the rate of return to agricultural R&D declined over time? [answer: no]
2. Do the returns to agricultural R&D differ internationally (a) among different regions in the world [answer: some], (b) between developed and developing countries [answer: no], or (c) between NARS and IARCs [answer: no]?
3. Does the return to research vary according to its problematic focus (e.g., NRM research versus plant breeding)? [answer: yes]
4. Does the rate of return vary between basic and more applied research, or between research and extension? [no clear answer on the first question, but reported rates on extension are lower]
5. Is systemic bias built into the estimates from particular evaluation techniques and estimation details, from other aspects of the analysis, or according to who performs the analysis (e.g. self-analysis versus external evaluation)?

Based on an econometric analysis, higher rates of return are indicated when the rate of return is:

1. Nominal versus real (i.e.. data adjusted for inflation);
2. Is ex post (versus ex ante);
3. Applies to field crops (versus all agriculture) ;
4. Is based on an implicit surplus measure rather than econometric derivation; or
5. Is based on an econometrically estimated supply shift with a short (versus long) lag.

Lower rates of return are indicated when:

1. The rate of return is for extension only (versus research only);
2. Both research and extension effects are included (relative to either alone);
3. The analyst is employed by a university (versus government);
4. The analyst is employed by the private sector (versus government);
5. The analyst's employer is unknown (versus government);
6. The research evaluation is a self-evaluation (rather than an independent evaluation);

7. The research is on natural resource issues, rather than agricultural other topics;
8. The research scope is for a program (versus a single project);
9. The research scope is for one or more institutions (versus a single project);
10. The evaluation is published in a refereed journal compared with less formal outlets;
11. Explicit surplus is measured without using either a pivotal or parallel supply shift; or
12. A longer gestation lag is used.

Despite all these nuances and insights, this study is often used as blanket evidence for the high returns to investments in agricultural research (about 40% on average).

Evenson, R.E. 2001. "Economic impacts of agricultural research and extension." In Gardner, B.L. and G.C. Rausser. (Eds). *Handbook of Agricultural Economics*, *Volume 1A: Agricultural Production*. Elsevier, New York, USA, pp. 573-628.

The late (2/2/13) Bob Evenson was one of the pioneers of economic impact studies regarding agricultural research and extension. This chapter includes a compilation of a large number of such studies, many of which are also captured by the Alston *et al.* study above.

Walker T., M. Maredia, T. Kelley, R. La Rovere, D. Templeton, G. Thiele and B. Douthwaite. 2008. *Strategic Guidance for Ex Post Impact Assessment of Agricultural Research*. Report prepared for the Standing Panel on Impact Assessment, CGIAR Science Council. Rome, Italy: Science Council Secretariat.

http://impact.cgiar.org/sites/default/files/pdf/7-Strategic-Guidelines.pdf

This study provides a good overview of recent developments in impact assessment methodologies. However, it does not attempt to indicate what best practices are but rather looks at the options and discusses their pros and cons as a prelude to offering 'good practice' advice at the end of each section. It differentiates impact assessment into two stages, namely: (i) Immediate impact (i.e., yield increases). This stage is relatively well covered by economic rate of return studies; and (ii) Long-term impact, which, by nature, is multi-dimensional (i.e., poverty reduction, employment, food security, etc.). The analysis of this stage is still relatively underdeveloped. But donors increasingly insist on documenting the long-term impact.

de Janvry, A., A. Dustan and E. Sadoulet. 2011. *Recent Advances in Impact Analysis Methods for Ex-post Impact Assessments of Agricultural Technology: Options for the CGIAR*. Rome: Independent Science and Partnership Council Secretariat.

http://impact.cgiar.org/sites/default/files/images/deJanvryetal2011.pdf

This study provides an overview of the latest developments in agricultural research impact analysis approaches and in particular at the micro level. Based on detailed household data and the like, these approaches try to develop insights into who is benefitting from particular technological innovations and who is not (e.g., non-adopters). It extensively discusses the use of random controlled trials, which has been a recent development.

Global Donor Platform for Rural Development. 2012. *Donor Methods to Prioritise Investments in Agricultural Research and Development.* Bonn: Secretariat of the Global Donor Platform for Rural Development.

http://www.donorplatform.org/agriculture-research-for-development/latest/816-platform-synthesis-paper-donor-methods-to-prioritise-investments-in-agricultural-research-and-development.html

"One objective of the agriculture research for development working group of the Global Donor Platform for Rural Development (Platform) is to improve knowledge of and harmonize donor methods to prioritise investments in agricultural research and development.

This report describes: (i) The context in which investments are selected in agricultural research; (ii) Reviews methods for agricultural research prioritization; (iii) Describes mechanisms donors use to program agricultural research resources; (iv) Suggests how donors might adjust their prioritization strategies to improve coordination and potentially increase impacts of their portfolios.

The decision to fund agricultural research versus other interventions can be guided by: (i) The need to evaluate donor investments in terms of their expected contributions to goals; (ii) The comparative advantage of agricultural research compared to other interventions; (iii) The order of the decision process; (iv) The complementarity of investments; (v) Differences in the time periods for investments; and (vi) The riskiness of investments.

Review of agricultural research priority setting methods

Agricultural research priority setting by donors involves: (i) Identifying and prioritizing donor goals; (ii) Defining the research alternatives to be prioritized; (iii) Projecting impacts or contributions (to donor goals) of research on the alternatives—considering the degree of risk and uncertainty associated with the impacts; and (iv) Comparing the alternatives and establishing priorities once impacts are estimated (projected). These four elements are included in research priority setting regardless of specific methods employed –although donors differ in the way they address them.

1. **Goals:** An array of donor goals is used in agricultural research priority setting. Agricultural research can be expected to contribute to some goals more than others and differs in its ability to achieve them as compared to the ability of other interventions. Meeting the goal of improved productivity, income and food security also contributes to other goals such as improved nutrition and health or sustainability of the natural resource base.
2. **Research alternatives:** Opinions of key stakeholders are important in defining the appropriate researchable alternatives. Information on what is possible to achieve through research should draw on appropriate, often multidisciplinary, scientific expertise. A participatory structured process that identifies key researchable problems and the potential contributions of different disciplines to them is essential.
3. **Impact assessment:** A key part of research prioritization is projecting the impacts that can be achieved through investment in different types of research. Quantitative assessments are preferred where confidence can be placed in the results, but the level of confidence differs depending on the nature of the research and the types of impacts. In some cases donor research budgets are largely aimed at strengthening national and international research institutions. Improvements in productivity or efficiency are among the easiest impacts to project quantitatively.
   Methods for projecting agricultural research impacts on nutritional and human-health wellbeing and on the natural resource environment are also available, but due to the multifaceted nature of nutrition, health and the environment, less confidence can be placed in the results.
   Impact assessment can absorb significant resources—so choices must be made on the level of rigor and resources to devote to assessing potential impacts of alternative research themes. For each donor goal, a few key factors determine the expected contributions of a research project toward achieving the goal. For the goal of improving agricultural productivity, income growth and food security, key factors include the current value of production, projected impacts of the research on yields and costs, the odds of success in the research, the likely adoption of the technologies and the timing of the benefits to be received. For the nutrition/health goal, the size of the target group, the incidence of the problem, the mortality rate or degree of disability associated

with the problem deficiency and the projected effects of the research on reducing the problem drive research benefits.
The impact of research on quantities produced and consumed and on prices paid affect nutrient consumption. Thus an economic assessment can also be a starting point for a health/nutrition assessment—the foods that make up the largest portion of the consumption of malnourished people are those that also may have the biggest impact on nutrition.
Key factors influencing poverty effects of research are: (i) The number of poor; (ii) The depth of their poverty; (iii) The income provided by the research results or technology; (iv) The adoption of the technology by the poor; and (v) Food price changes affecting consumers.
The environment is multidimensional but a practical method for assessing environmental sustainability is to assess the physical effects of the research on specific environmental categories. Availability of data to support environmental impact assessment varies by category of environmental impact and the data are often rough.
Donors must consider the extent to which the research should be a public rather than a private responsibility. Another factor is the extent to which other donors are supporting research on a topic and the comparative advantage of the donor on the research themes.

4. **Comparing alternatives:** Tradeoffs must be considered with respect to research contributions to different objectives. The potential impacts of a research portfolio that emphasizes one objective versus another can be assessed and then how much the contribution of the portfolio to one objective would be reduced if the other objective is emphasized to differing degrees. To address the benefits of specific research options under varying levels of funding, research benefits can be projected under a high, medium and low level of funding for each alternative. Research that is already in the pipeline must be compared to new research.

Donor consultations

Informal consultations were held with representatives from seven donor organizations to discuss their current priority setting mechanisms. Representatives were interviewed from BMZ, GIZ, CIDA, DFID, EC, OECD, USAID and the Gates Foundation. Most donors reported using informal processes to set priorities because they lacked capacity, resources, or staff time to conduct formal, technical priority-setting exercises.

Some donors have at times engaged in formal priority setting but not on a regular basis. Donors indicated that the provision of reliable evidence was their most important criterion in evaluating priority setting mechanisms. Several interviewees hinted that easier-to-use methods might lead to more widespread formal priority setting.

Donors had a favorable impression of analytical methods but none uses them on a regular basis. Some stated that increased sharing of experience among donors and formal collaboration with other donors might improve their ability to utilize these methods. Few have in-house capability to conduct the exercises. Some were concerned that the evidence base—in favor of agricultural research—was weak for non-efficiency objectives. They felt that much of the academic priority setting literature focused too closely on efficiency, while many politicians currently favored non-efficiency objectives. They are concerned about tradeoffs between objectives and would like means of evaluating these tradeoffs when setting research priorities.

Mechanisms for investments in agricultural research

Donors engage a variety of institutions to conduct agricultural research for development, including the CGIAR system, universities, government agencies, NGOs, private research organizations and others. While the distribution of resources among institution type varies from donor to donor, it is clear that the bulk of research resources pass through the CGIAR system.

Reasons for this dependence on the CGIAR include: (i) Confidence in the quality and relevance of CG-led research; (ii) Close correspondence between CGIAR goals and donor goals; (iii) The ability of CG centers and CRPs to link with other actors including NARS and university researchers; (iv) The ease of contracting with the CGIAR and its ability to conduct large-scale, multidisciplinary research.

Donors are also increasingly partnering with applied research entities that can deliver research results to end users.

The report closes with the following recommendations for donors: (i) Systematize the prioritization process; (ii) Contract with appropriate groups to project impacts; (iii) Insist the CGIAR does more on priority setting; (iv) Make use of accepted theory and available information; (v) Use quantitative tools where practical and credible; (vi) Ensure that priority setting methods help to lead to tangible results in farmers' fields." A slightly elaborated version is reported in the related Policy Brief as follows.

Systematise the prioritisation process

A five-step sequence of practices can be useful for setting priorities for most donors: (i) Identify goals; (ii) Specify potential alternatives (topics or institutions) to be prioritised; (iii) Project contributions of research topics (institutions) to the goals; (iv) Consider tradeoffs associated with alternative priorities; and (v) Compare priorities to the current portfolio of topics or institutional investments and vet any changes against political acceptability.

Projecting contributions of research to specific goals can be accomplished by applying a subset of impact assessment tools, can make use of the results from meta-analyses of previous research on the topics, or can make use of indicators or theory. A formal prioritisation process is not completed each year but should be undertaken when a new strategic plan is developed or at least every five years. Adjustments to priorities can be made more frequently, and targeted impact assessments can be undertaken to inform those changes. To effectively prioritise research investments, it is critical to understand potential impacts for different research investments by using various methods for research impact assessment.

CGIAR Standing Panel on Impact Assessment website

http://impact.cgiar.org/

The SPIA website functions as the hub within the CGIAR (and the wider NARS community) to share information and experiences regarding agricultural research impact. Within SPIA there is a long-standing debate between those who adhere to econometric approaches to measure impact and those that believe that we should use other, more qualitative approaches. The basic dispute is about whether an innovation process can be captured in a strict linear fashion (the econometric approach) or that it is a far fuzzier, path dependent process. Adherents to the first approach believe that technology can offer the silver bullet solution without paying much attention to the context (hence the focus on research investment), while adherents to the second approach believe that for a technology to work a lot of factors other than research investment come into play as well. In their vision, creating the right conditions for innovation is key.

Despite this critique on the econometric approach, it is a relatively dynamic field that permanently tries to improve its methods. The use of randomized controlled trials in impact studies, for example, is just one of the latest developments, which is heavily debated.

Fuglie, K.O., S. L. Wang and V. E. Ball (eds.), *Productivity Growth in Agriculture: An International Perspective*. Wallingford: CABI.

"Increasing food prices have renewed concerns about long-run agricultural demand and supply in the global economy. This book looks at results, methods, and data on international agricultural productivity

for a better understanding of long-run trends and the policies that determine them. By presenting an international assessment of total factor productivity growth in agriculture, including up-to-date empirical analysis for developed and developing countries and regions, it provides a response to the rising global scarcity of agricultural production." (CABI)

Fuglie, K. and S.L. Wang. 2012. "Productivity Growth in Global Agriculture Shifting to Developing Countries." *Choices* 27(4) (AAEA)

http://www.choicesmagazine.org/choices-magazine/submitted-articles/productivity-growth-in-global-agriculture-shifting-to-developing-countries

"The 15 case studies published in Fuglie, Wang and Ball (2012) investigate agricultural productivity growth and its drivers across a broad swath of the globe. Included are developed countries (the United States, Western Europe, Canada, Australia and South Africa), developing countries and regions (Brazil, China, India, Indonesia, Thailand and Sub-Saharan Africa), and transition countries (Eastern Europe and the former Soviet Union). Taken together, the case studies point toward robust but highly uneven productivity growth in global agriculture. …

The TFP measure of productivity change captures a broader set of productivity improvements—including those that save agricultural resources other than land. It does not count as productivity growth simple substitution between inputs—fertilizer for land or machinery for labor, for example, if this doesn't save costs. Thus, TFP provides a better measure of the underlying rate of technical change. And according to our estimates, the average rate of technical change (TFP) in global agriculture rose significantly over the past half-century. The growth rate in aggregate inputs used in agriculture, meanwhile, fell steadily. Over the past five decades, the source of growth in the global agriculture output has shifted dramatically from being primarily resource-driven to primarily productivity-driven. …

In addition to R&D, new econometric evidence from the Fuglie, Wang, and Ball (2012) volume has identified a number of other factors that have contributed to cross-country differences in agricultural TFP. This can broadly be characterized as the "enabling environment" for the dissemination of new technologies and practices. These factors include policies that improve economic incentives for producers, stronger rural education and agricultural extension services, and rural infrastructure improving access to markets. At the same time, economically disruptive "shocks," such as armed conflict and human or animal diseases—HIV/AIDS in Africa and avian flu in Asia—have seriously depressed agricultural productivity growth in some countries. Having a more favorable enabling environment compliments but does not substitute for research. Improving on these enabling factors raises the return to investments in agricultural R&D.

Future challenges to world food security, as in the past, do not appear to be related to technical constraints to raising agricultural productivity at the global level, but rather to uneven access to resources, technologies and food. Regions that have lagged behind the agricultural technology frontier, like much of Sub-Saharan Africa, have remained mired in poverty and food insecurity. These countries could follow the examples of agricultural success stories like Brazil and China, which invested heavily in agricultural research, made critical reforms to policies and institutions, and tapped into international sources of agricultural technology to raise their farmers' productivity, lower food prices for consumers, and stimulate economic growth. When a country's population shares broadly in these developments, it can have a major impact on poverty reduction and improving societal well-being."

Chapter 5: Re-visiting NARS organization and management

NARS typology and analysis

Trigo, E.J. 1986. *Agricultural Research Organization in the Developing World: Diversity and Evolution*. Working Paper No. 4. The Hague: ISNAR.

This paper sets out by introducing five basic operational options for the organization of agricultural research, namely:

1. The ministry model;
2. Autonomous of semi-autonomous institute ;
3. The university model;
4. The agricultural research council.
5. Private sector research organizations (including commodity board type of research agencies).

Jain, H.K. 1989. *Organization and Structure in National Agricultural Research Systems*. Working Paper No. 21. The Hague: ISNAR.

This ISNAR working paper elaborates on the Trigo paper, but takes more of a NARS perspective. It introduces a set of key functions that a NARS should perform. This is further elaborated in Working Paper No. 23 (see below). The author highlights the following themes as crucial in the development of more effective NARS: (i) Creation of planning capacity; (ii) Decentralization; (iii) Inter-institutional coordination; (iv) Commitment to development; (v) Improvement in the Board structure; (vi) Linkages with the private sector; and (vii) Rationalization of the research station network. This ISNAR working paper was the first of several working papers that looked at the organization and structure of NARS in different regions (No. 31: Arabic countries; No. 32: Asian countries; No. 33: Sub-Saharan countries; No. 38: Anglophone sub-Saharan African countries; etc.).

Eyzaguirre, P. 1996. *Agriculture and Environmental Research in Small Countries: Innovative Approaches to Strategic Planning*. Chichester, UK: John Wiley & Sons.

This book is the result of a multi-year ISNAR study into the specific problems of small countries (population of less than 5 million) to provide public agricultural research services. The main recommendation of this study is that NARS in small countries should define their role differently than NARS in large countries. They should place more emphasis on technology acquisition and less so on research and technology generation. Moreover, larger NARS can afford more specialization – in small NARS scientists have to be more generalists and perform multiple roles simultaneously.

ISNAR's critical factors

Dagg, M. and P.B. Eyzaguirre. 1989. *A Methodological Framework for ISNAR Reviews of National Agricultural Research Systems (NARS)*. Working Paper No. 23. The Hague: ISNAR.

This working paper, based on ISNAR's experience of reviewing some 40 NARS between 1981 and 1988, draws lessons from these experiences and proposes a standard framework for future NARS reviews. This framework proposes the following 12 critical factors to be studied in order to assess the effectiveness of the system:

Policy

1. Interactions between national development policy and national agricultural research;
2. Formulating of research policy: priority setting, resource allocation, long-term planning;

Structure and organization

3. Structure and organization of research systems;
4. NARS linkages with policymakers;
5. NARS linkages with extension, clients and farmers;
6. NARS linkages to sources of world knowledge and technology;

Management

7. Program formulation and program budgeting;
8. Monitoring and evaluation;
9. Information management;
10. Development and management of human resources;
11. Development and management of physical resources; and
12. Acquisition and management of financial resources.

From the outset, ISNAR had a strong focus on improving management of NARS, such as captured in its early collaboration with the Economic Development Institute of the World Bank (Elz 1984).

Elz, D. ed. 1984. *The Planning and Management of Agricultural Research: A World Bank and ISNAR Symposium*. Washington, D.C.: World Bank.

Papers presented at a seminar held Oct. 31-Nov. 10, 1983, sponsored by the Economic Development Institute of the World Bank and the International Service for National Agricultural Research.

During its existence, ISNAR produced a considerable number of publications that target specific critical factors, including several thematic 'sourcebooks' such as:

Kaimowitz, D., ed. 1990. *Making the Link: Agricultural Research and Technology Transfer in Developing Countries*. Boulder: Westview Press.

Horton, D., P. Ballantyne, W. Peterson, B. Uribe, D. Gapasin and K. Sheridan, eds. 1993. *Monitoring and Evaluating Agricultural Research: A Sourcebook*. Wallingford, UK: CABI International.

Tabor, S.R., W. Janssen and H. Bruneau, eds. 1998. *Financing Agricultural Research: A Sourcebook*. The Hague: ISNAR.

Vernon, R. 2001. *Knowing Where You're Going: Information Systems for Agricultural Research Management.* The Hague: ISNAR and CTA.

Gijsbers, G., W. Janssen, H. Hambly Odame and G. Meijerink, eds. 2001. *Planning Agricultural Research: A Sourcebook*. Wallingford, UK: CABI Publishing.

Two topics that were not explicitly covered by ISNAR's 12 critical factors, but that have received a lot of attention in recent years are intellectual property rights (IPR) and defining the (changing) roles of public and private actors in agricultural research.

Intellectual Property Rights

World Bank. 2006. *Intellectual Property Rights: Designing Regimes to Support Plant Breeding in Developing Countries*. Washington, DC: World Bank.

http://siteresources.worldbank.org/INTARD/Resources/IPR_ESW.pdf

"Increased attention has been given in the past decade to strengthening intellectual property rights (IPRs) in plant breeding. The number of countries that grant such rights has grown, the types of inventions that can be protected have expanded, and the scope of protection offered by extant IPR systems in different countries has also broadened. The Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS 1993) of the World Trade Organization (WTO) requires all WTO members to introduce at least a minimum level of protection in their national laws for plant varieties and inventions in biotechnology. Least Developed Countries recently managed to extend the deadline to 2013 for bringing their national IPR laws fully up to the TRIPS standards.

Even so, this extension does not diminish the pressure to develop IPR legislation for plant varieties in several countries, because bilateral trade negotiations between developing countries and the USA or EU often include requirements that go beyond the TRIPS requirements (the so-called "TRIPS-plus" requirements). These developments towards strengthened IPRs arise from a trade perspective rather than from a perspective of increasing innovation in the developing countries concerned.

Plant breeding research and seed provision are vital industries that need to be fostered and stimulated. Plant breeding is important for food security at the local and global levels; the ability of adapted varieties to cope with environmental stresses contributes to strategies for sustainable agriculture, and the provision of productive options for commercial farming is essential for wider economic development. The twin challenges are first to understand the degree to which stronger IPRs in plant breeding can help stimulate these industries and second to determine whether the IPR systems for plant varieties that have been developed in industrialized countries can contribute to development objectives."

This report, which is based on a field study of the impact of strengthened IPRs on the breeding industries in China, Colombia, India, Kenya, and Uganda, looks into the differences in IPR regimes adopted and how it affects plant breeding by commercial seed companies and public agricultural research organizations.

The following lessons were claimed by this study:

- "IPRs should not be considered a silver bullet for commercial seed industry development. Because seed systems differ widely among countries and also within countries, between crops, and across regions, blueprint advice cannot be given to policy makers on how to design the ideal IPR system for plant breeding. Rights that are excessively broad in scope may obstruct the flow of technologies to resource-poor countries and farmers. On the other hand, IPRs may contribute to the development of commercial seed systems in certain sectors, and they may assist in the creation of effective public-private partnerships. This outcome will materialize, however, only when other conditions for business development are favorable.
- Pressure to strengthen IPRs in plant breeding in developing countries presents both immediate and long-term challenges to policy makers and donors. The immediate challenges are related to framing and implementing appropriate legislation that is consistent with TRIPS and that supports national agricultural development goals. The longer-term challenges are derived from the fact that an IPR regime, on its own, is not likely to provide the incentives that elicit the emergence of a robust plant breeding and seed sector; attention to other institutions and the provision of an enabling environment are also necessary.
- National policy makers must give immediate attention to the establishment and implementation of appropriate IPR legislation for plant breeding. Several *sui generis* models are available, including the UPOV Conventions, but even reliance on a model requires a number of choices. The most important parameters to determine are related to seed saving, seed exchange, the scope of protection, the breadth of coverage, and the relation of PVP and patents to the concerns of

Farmers Rights. These parameters deserve careful consideration before a decision is made on the use of a particular model for national legislation. Policy makers must also consider cost-effective means for implementing an IPR regime and ensuring that the IPR system is consistent with enforcement capabilities.

- If they are to have their intended effect, IPR systems in plant breeding must be tailored to the conditions of national seed systems. Even within a single country, the requirements and conditions of different crop production systems are not uniform, and countries may consider legal options that address this variability. For example, strong protection may be provided for export agriculture and weak or no protection for noncommercial sectors that primarily cater for subsistence farmers.
- The absence of commercial incentives in noncommercial sectors, however, creates a (continued) responsibility for public investments in plant breeding and seed support systems. Systems for PVP contain flexibility to balance benefits for breeders and farmers—a flexibility that is much more difficult to create within patent systems. Some patent systems have created openings for flexibility, however, either by excluding certain inventions from patentability or certain claims from being honored, or by providing explicit exemptions when protection may unduly affect farmers.
- Developing IPRs for biotechnology in plant breeding requires greater attention to strengthening capacities in national patent offices. Countries that use transgenic varieties will need to ensure adequate protection, although in many cases credible enforcement of the right combination of biosafety regulations, seed laws, and PVP may offer adequate protection for transgenic varieties, at least in the early stages of their availability in developing countries.
- Policy makers must recognize that the development of a commercial seed sector depends on attention to other factors in the enabling environment, including seed regulations and the growth of agribusiness. Particular attention is also needed to ensure that policies encourage NARIs to fulfill their public sector mandate while taking advantage of IPRs to gain access to technology, guide the diffusion of their varieties, and, where appropriate, earn royalties.
- The World Bank can assist developing countries by providing immediate support to national efforts at developing and implementing PVP legislation as well as by instituting longer-term strategies that foster the development of seed sector institutions. In the short term, the Bank can support opportunities for national (or, where relevant, regional) forums that promote debate and discussion about the shape of PVP legislation and its implementation.
- Discussions should emphasize (1) the necessity of structuring IPR regimes to evolve in concert with national seed systems, including the possibility of providing different levels of protection to different crops, and (2) the importance of key parameters within IPR models. The Bank can also sponsor meetings and other activities that explore possibilities for regional collaboration in the administration and management of PVP, and it can encourage stronger regional mechanisms for patent applications, including those in biotechnology. In addition, the World Bank can support further research that monitors experience with IPRs in developing countries and that examines issues related to the cost effective management of IPR regimes.
- There are also longer-term opportunities for the Bank to support the growth of seed sector institutions. Capacity building in national PVP and patent offices, as well as support for effective seed regulatory regimes, will be useful. Capacity building for regional collaboration is needed in both the IPR and seed regulatory domains. Bank supported agribusiness projects should include reviews of IPR regimes and their implications for project success. World Bank support for NARIs should help develop adequate IPR policies and strategies, encourage more effective interaction with the private seed sector, and build competence in accessing protected technology."

Public-private partnerships in agricultural research

Fuglie, K.O. and D.E. Schimmelpfennig. 2000. *Public-Private Collaboration in Agricultural Research: New Institutional Arrangements and Economic Implications*. Ames, Iowa: Iowa State University Press.

This publication focuses in particular on the situation in the USA, but from it various lessons can be drawn regarding the role of IPR, joint public-private initiatives, and the shifting balance in public and private agricultural research.

Byerlee, D. and R.G. Echeverría, eds. 2002. *Agricultural Research Policy in an Era of Privatization*. Wallingford (UK) and New York: CABI Publishing.

"This book provides contemporary experience on public and private sector roles in funding and executing agricultural research in an era of increasing privatization of economic activities. The book is built around a series of case studies of recent changes, with emphasis on developing countries."

"While the theme of the book is the change brought about by the growing privatization of all sectors of the economy, including agricultural R&D, the chapters also reveal the limits to private R&D, especially in developing countries. The role of public funding and to a lesser extent public execution of research must remain central, especially where non-commercial agriculture is important and research institutions are weak."

"Nevertheless, the case studies reveal a rich experience in institutional innovations in financing and execution of research that have, in many cases, reinvigorated agricultural research systems. Often these innovations involve increased collaboration between public and private sectors, including farmers, which increases the efficiency and effectiveness of public organizations. The increasing tendency to look beyond agricultural research is also providing new opportunities to link public funding and public research organizations into a wider innovation system."

NARS reforms

Byerlee, D. and G.E. Alex. 1998. *Strengthening Agricultural Research Systems: Policy Issues and Good Practices*. Washington, DC: World Bank.

http://books.google.fr/books?id=st40r0qenVEC&pg=PA11&hl=fr&source=gbs_toc_r#v=onepage&q&f=false

"This report has two objectives. First, it provides a brief review of recent trends and key policy issues in strengthening national agricultural research systems - broadly defined to include national research institutes, universities, the private sector, and nongovernmental organizations. Second, it synthesizes good practice in ongoing institutional and policy reforms in the subsector. The report explores agricultural research policy issues and provides a resource on selected research policy and management issues for Bank staff and partners in borrowing countries. Most of the practices represented here have been incorporated in recent Bank projects in various forms. For complex issues, such as agricultural research policy, best practices are often very situation specific. Agricultural research policy and best practices will continue to evolve in response to the changing roles of the public and private sectors, new institutional mechanisms for funding and executing research in the public sector, and changing demands on research systems. The World Bank will closely monitor ongoing experience in research projects, and modify best practices in light of these experiences."

Michelsen, H., L.W. Zuidema, C.H. Hoste and D. Shapiro. 2003. *Improving Agricultural Research at Universities in Sub-Saharan Africa: A Study Guide.* The Hague: ISNAR.

"Universities in sub-Saharan Africa have been widely criticized for being too academic and remote from the practical needs of the societies that they are supposed to serve. Yet these universities often include among their faculty a great proportion of their country's most highly trained researchers, and some of the best research facilities. How can these resources best be mobilized to contribute to national development objectives? The question is especially acute in the agricultural sector, where national agricultural research organizations, which have previously supplied the innovations on which sustainable development depends, have been severely weakened by cuts in public-sector spending. This report provides a wealth of practical help for policymakers and agricultural research leaders who have recognized the need for reform but who may be wondering how best to proceed. It synthesizes the experience of six countries and a review of the experiences of other major development organizations, and provides a conceptual framework for reform that recognizes the dual research-and-education mandate of universities and the complementary roles of universities and other research organizations. The paper offers a practical "road map" to guide the review-and-change process, complete with a comprehensive set of decision-support tools and numerous real-world examples."

Lynam, J. 2012. "Agricultural Research within an Agricultural Innovation System." Module 4 in *Agricultural Innovation Systems: An Investment Sourcebook*. Washington, DC: World Bank.

http://siteresources.worldbank.org/INTARD/Resources/335807-1330620492317/9780821386842_ch4.pdf

"Investing in agricultural research within an AIS framework complements the traditional internal focus on capacity and research priorities with an external emphasis on better articulation of client demand and effective institutional partnerships. Agricultural research as a producer of new knowledge requires effective institutional arrangements to apply that knowledge. The types of organizations and nature of these partnerships in the generation of innovation will depend on the market orientation of the agricultural sector and private investment in agro-industry. In urban and transforming economies, these institutional partnerships will tend to focus on research linkages to agricultural input or processing industries, often within the frame of public- private partnerships, including technology transfer arrangements, and often facilitated by public financing arrangements. Such research linkages to the private sector and other actors will tend to be organized around clusters, and financing will often be in the form of competitive grants with co-financing from the private sector.

In agrarian economies, on the other hand, external connectivity of research is primarily through bridging organizations, particularly extension services, farmer associations, trade associations, and NGOs, and farmer demand is articulated through nonmarket mechanisms with farmer representation. The latter tend to involve novel organizational arrangements, such as farmer councils and innovation platforms, new methodologies, organizational change within research institutes, and financing arrangements that support the increased transactions costs inherent in improved external connectivity. Farmer participation in the co-design of innovations is characteristic of these organizational arrangements, and it may be facilitated by innovation brokers. Financing is almost solely based on public sources and will tend to be organized around research foundations or agricultural research councils. There is an inherent tendency for research within an AIS to focus on market-driven applications, often within a value chain framework, and particular strategies are required to ensure that research continues to contribute to the reduction of rural poverty."

New public management

World Bank. 1998. *Reforming Agricultural Research Organizations*. AKIS Good Practice Note 01/99. Washington, DC: World Bank.

http://siteresources.worldbank.org/INTARD/825826-1111470888913/20431987/Reforming_ARO.pdf

Paper based on a consultancy report by John Nickel and focuses on the 'autonomy' of agricultural research organizations. The same report has found its way into several NPM overview studies and is cited quite frequently outside the agricultural research literature.

Gill, G.J. and D. Carney. 1999. "Competitive Agricultural Technology Funding in Developing Countries." ***ODI Natural Resource Perspective*****, No. 41.**

http://www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publications-opinion-files/2406.pdf

"Dissatisfaction with traditional mechanisms of funding agricultural research and dissemination (AR&D) in developing countries has led to the introduction of competitive agricultural technology funds (CATFs) in an increasing number of them. This model is now favoured by many donors, despite the fact that available information on its modalities and performance has been fragmentary. This paper reviews experience with ten such funds in very different national and institutional settings."

Chema, S., E. Gilbert and J. Roseboom. December 2003. ***A Review of Key Issues and Recent Experiences in Reforming Agricultural Research in Africa*****. ISNAR Research Report No. 24. The Hague: ISNAR.**

ftp://ftp.cgiar.org/isnar/publicat/pdf/RR-24.pdf

This study provides an overview of the NARS reforms in Africa initiated by the World Bank in the early 2000s. It makes the case that many of the proposed reforms are based in NPM thinking. For the recipient countries it helps to understand the origins of the ideas and understand both their strength and weaknesses.

World Bank. 2006. ***Institutional Innovation in Agricultural Research and Extension Systems in Latin America and the Caribbean*****. Washington, DC: World Bank.**

This study focuses in particular on the introduction of competitive funding schemes (an NPM instrument) in agricultural research in Latin America and the Caribbean.

Rivera, W.M. and W. Zijp. 2002. ***Contracting for Agricultural Extension: International Case Studies and Emerging Practices.*** **Wallingford (UK) and New York: CABI Publishing.**

Chapter 6: Re-considering research approaches

Reductionism versus holism

Østreng, W. 2007. "Reductionism versus Holism – Contrasting Approaches?" In ***Consilience. Interdisciplinary Communications 2005/2006.*** **Oslo: Centre for Advanced Study.**

http://www.cas.uio.no/Publications/Seminar/Consilience_Ostreng.pdf

This paper gives a good introduction into the reductionism versus holism debate in research in general.

Vanloqueren, G. and P.V. Baret. 2009. "How Agricultural Research Systems Shape a Technological Regime that Develops Genetic Engineering but Locks out Agroecological Innovations." ***Research Policy*** **Vol. 39: 971-983.**

http://www.co.lake.ca.us/assets/bos/ge+crops+committee/agricultural+research+systems.pdf

"Agricultural science and technology (S&T) is under great scrutiny. Reorientation towards more holistic approaches, including agro-ecology, has recently been backed by a global international assessment of

agriculture S&T for development (IAASTD). Understanding the past and current trends of agricultural S&T is crucial if such recommendations are to be implemented. This paper shows how the concepts of technological paradigms and trajectories can help analyze the agricultural S&T landscape and dynamics.

Genetic engineering and agro-ecology can be usefully analyzed as two different technological paradigms, even though they have not been equally successful in influencing agricultural research. We used a Systems of Innovation (SI) approach to identify the determinants of innovation (the factors that influence research choices) within agricultural research systems. The influence of each determinant is systematically described (e.g. funding priorities, scientists' cognitive and cultural routines etc.). As a result of their interactions, these determinants construct a technological regime and a lock-in situation that hinders the development of agro-ecological engineering. Issues linked to breaking out of this lock-in situation are finally discussed."

From farming systems to value chains

Collinson, M., ed. 2000. *A History of Farming Systems Research*. Rome: FAO and CABI Publishing.

http://books.google.nl/books?id=3OyMszpzu_QC&printsec=frontcover&hl=nl&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

This book gives an excellent overview of the development of farming systems research from the late 1960s until 2000. It comprises contributions from a large number of farming system research specialists. While initially developed merely as a diagnostic tool (the 'farm household' as objective of study), over the years the approach became increasingly more participatory.

Merrill-Sands, D. and D. Kaimowitz. 1989. *The Technology Triangle Linking Farmers, Technology Transfer Agents, and Agricultural Researchers*. The Hague: ISNAR.

http://pdf.usaid.gov/pdf_docs/PNABG413.pdf

This publication summarizes the highlights of two major studies conducted by ISNAR in the late 1980s, namely: the Study on the Organization and Management of On-Farm Client-Oriented Research (OFCOR) and the Study on Research-Technology Transfer Linkages (RTTL). The OFCOR study is in particular relevant as it looks into the organization and management issues that research organizations have to deal with when aiming 'OFCOR' type research.

"Links between agricultural research institutes and their clients -farmers and technology transfer agencies -are vital for successful technology development and delivery. Direct links with farmers, developed through on-farm research, ensure relevance and rapid feedback. Links with technology transfer agencies ensure impact through a wider dissemination of technologies. The two sets of links are complementary and both are necessary: one cannot substitute for the other. Research managers have found these links difficult to organize and sustain, particularly when addressing the needs of resource-poor farmers. Yet experience has shown that weak links have costs few developing country research systems can afford. Linkage problems not only reduce efficiency, they also impair performance and diminish the impact of agricultural research.

This document summarizes the presentations and discussions of an international workshop. The workshop was convened to review the findings of two on-going studies on how to strengthen links with farmers and technology transfer agencies. These studies, conducted by ISNAR in collaboration with a wide range of NARS, have focused on five key areas.

Policy and institutional context of links

There is no single recipe for strengthening links. The policy and institutional context determines the types of strategies and mechanisms a manager can use to develop effective links. Key contextual factors influencing links are: agricultural development and research policies; the resource situation and organizational structure of the institutions involved; and technical issues such as the existing knowledge base, the inventory of available technologies, and the diversity of agro-ecological conditions and production systems.

The policy context in which an institution operates is shaped mainly by external pressures from national policy-makers, foreign donors, the private sector, and, in some cases, farmers' organizations**.** These pressures can stimulate institutions to improve performance, build stronger links, and address the needs of resource-poor farmers. However, they do have limitations. They tend to focus on short-term goals and often overestimate the capacity of local institutions to meet new demands.

Organizational factors affecting links

When developing linkage strategies, research managers need to consider organizational structure both as an entity within which they have to maneuver and as a variable they can manipulate. The size of an institution is a critical factor affecting links. Small institutions, for example, can benefit more from informal links among staff. Yet they often face severe resource constraints in terms of staff and funds, and have trouble sustaining even the most basic linkage mechanisms.

A second key factor, particularly for larger, more complex institutions, is how tasks and responsibilities are divided among organizational units. Merging research and technology transfer or on-farm and on-station research into one department or institution is often proposed as a solution to linkage problems. This can be successful, but only under certain conditions. The groups must share a common focus, such as a single commodity; they must have the same level of commitment to working together towards a common goal; and the institutions should not be too large. Although separating groups into different units sets up organizational barriers, it has some important advantages. It encourages specialization and the development of expertise, and often permits closer supervision and leadership. Which approach is more appropriate depends on the context.

Three types of structural mechanisms are commonly used to establish links between separate, but interdependent units: direct supervision by a common manager; coordination units or positions; or permanent committees made up of representatives from the relevant groups. In this document, each mechanism is reviewed in terms of its advantages and disadvantages and respective management.

Types of linkage mechanisms

In addition to structural interventions, managers can use four basic types of mechanisms to strengthen links: joint planning and review processes; collaborative professional activities; resource allocation procedures; and communication devices. The analysis shows that these various types of mechanisms are appropriate for different kinds of linkage problems, have distinct managerial and resource requirements, and vary in ease of implementation. Moreover, different types of technologies require different types of linkage mechanisms.

To build effective links with technology users, managers need to use a combination of various mechanisms and apply them at different levels of the institutional hierarchy. At the same time, recognizing that all linkage mechanisms cost time and money, managers need to choose them carefully, apply them frugally, and adapt or replace them with new mechanisms as technologies and institutional conditions change. Above all, managers need to provide leadership and hands-on management in developing links.

Staff management issues

In the end, links are about people. No linkage mechanism can succeed unless staff working on research stations, on farms, and in technology transfer agencies are motivated to collaborate. The challenge for managers is to get these staff, with their differing backgrounds, skills, aspirations, and responsibilities, to work together and to recognize that they depend on one another to reach a common goal.

Perceived status differences between researchers and technology transfer workers, or even on-farm workers, often impede collaboration. Status problems have no simple solutions. Managers have three basic options: reduce the differences through training or increased professionalism; accept the difference, but work to minimize their negative impact; or, in very difficult situations, avoid status problems by finding alternative partners or building up their own capacity in technology transfer.

The need for active management

Managers make the difference between strong and weak links. Active management means providing leadership, maintaining flexibility and responsiveness, and having the ability to manage conflict.

Managers who are committed to strengthening links shape their institutions to create the conditions necessary for productive collaboration. They work with the groups to develop a common goal and sense of mission and to clearly define their respective responsibilities and tasks. They promote mutual respect and a feeling of interdependence between the groups. And they make sure that all staff, not just the managers, feel that they benefit personally from collaboration."

Bernet T., G. Thiele and T. Zschocke, 2006. *Participatory Market Chain Approach (PMCA) – User Guide*. International Potato Center (CIP) – Papa Andina, Lima, Peru.

The Participatory Market Chain Approach (PMCA) stimulates networking, links small farmers to markets and fosters productive partnerships based on trust and knowledge sharing. Active participation - or a lack of it - by the many actors along the food chain can make or break the system. PMCA systematically involves people in identifying and assessing market opportunities and identifying commercial, technical and institutional innovations. A poverty filter helps identify the greatest probabilities of pro-poor impact.

Adekunle, A.A., J. Ellis-Jones, I. Ajibefun, R.A. Nyikal, S. Bangali, O. Fatunbi and A. Ange. 2012. *Agricultural Innovation in Sub-Saharan Africa: Experiences from Multiple-Stakeholder Approaches.* Accra, Ghana: FARA.

www.fara-africa.org/media/uploads/library/docs/fara_publications/agrl_innovations_in_ssa.pdf

"This review seeks to assess the usefulness of innovation systems approaches in the context of IAR4D in guiding research agendas, generating knowledge and use in improving food security and nutrition, reducing poverty and generating cash incomes for resource-poor farmers. The report draws on a range of case studies across SSA to compare and contrast the reasons for success from which lessons can be learned.

Twenty-one case studies, six in Eastern Africa, eight in Southern Africa and seven in West Africa including five supported by FARA's SSA Challenge Programme Pilot Learning Sites (SSA CP PLS), were used to assess the usefulness of multiple stakeholder innovations systems approaches.

These case studies were drawn from: (i) Traditional sectors including subsistence crops; (ii) Niche sectors involving special crops: (iii) Sectors integrated into global markets through export commodities; and (iv) Sectors offering large employment opportunities for the poor, aimed at either local or export commodities.

Prior to starting an innovation process each case study faced a wide range of challenges. Key ones included weak institutional structures, often with little or no contact between stakeholders. In most cases a lack of farmer organisations hampered farmers taking the initiative. Such problems were compounded by poorly developed markets, poor infrastructure and a lack of knowledge, or by inadequate extension often associated with inappropriate research. Consequently, use of unsuitable varieties and poor management practices with limited access to input or output markets resulted in low, often declining, yields and low incomes for farmers.

Stakeholders came from the entire spectrum of public, private, non-governmental organisation (NGO) and community-based actors across the economy with roles that often evolved over time. Interaction, collaboration and coordination featured in each case study. Often these were achieved through a facilitation process that assisted in bringing the actors together; in changing attitudes and building partnerships based on shared concerns and a need to identify opportunities for improvement. In some cases farmers themselves took an active role in the early stages, but in most the public sector was the dominant stakeholder, often providing research and other support. However, in some cases it was NGOs or private commercial companies who took the early initiative. Donor-funded support played an important role in most cases.

The case studies demonstrated that successful innovation is dependent on a wide range of factors and interventions, the most important being the existence or creation of a network of research, training and development stakeholder groups drawn from public, private and NGO sectors. Such groups need to have the capacity, capability and willingness to interact and work together in an environment that encourages cooperation, builds trust and establishes a common vision for the future. For this to occur, the participation of effective and representative farmer organisations able to communicate with members who often require support and capacity development was very important. Facilitation is frequently required to encourage: dialogue, joint planning, agreement on partner roles, and implementation responsibilities. It is also necessary to promote collaborative learning and assessment. Although research is an important component, it may not be the central one, while in the early stages of intervention, access to and use of existing knowledge and learning processes is essential. Ultimately, local participants build sustainability on ownership with effective back up from research and development organisations from both private and public sectors.

All of the 21 case studies had succeeded to a greater or lesser extent, although there were often new challenges that needed to be addressed to ensure long-term sustainability. Eleven cases could be regarded as sustainable, while the other ten were still addressing ownership by local participants.

Key factors contributing to success

The case studies demonstrated that successful multiple stakeholder approaches are dependent on a wide range of facilitating and inhibiting factors. Enabling public policies and regulations, including deregulation of markets, whilst ensuring competition and compliance with minimum standards, often provide a solid foundation. The creation of a network of stakeholder groups drawn from both public and private sectors is a prerequisite. Such groups need to have the capacity, capability and willingness to interact and work together in an environment that encourages cooperation, builds trust and establishes a common vision for the future. The establishment and participation of effective and representative farmer organisations able and willing to communicate with members is vital. In most cases this required support and capacity development.

Clearly, improved infrastructure, particularly roads, communication and power provide the basis for ensuring inputs can be made available at affordable prices and outputs delivered to market. This was often a precursor in seeking opportunity to add value along market chains.

Although research can be an important component, it is often not the central one, and in the early stages, interventions to build capacity, access and use existing knowledge, and foster learning are required. Easy and timely access to inputs, including finance, is crucial and needs to be based on effective and competitive marketing, whether domestic or export, and to address social and environmental concerns.

Looking to the future

As Africa faces the challenge of creating favourable conditions to enable the innovation required to stimulate poverty reduction and agricultural growth, the context for this is changing. Increasing population, rapid urbanisation, land resource degradation, climate change and the present disarray in world commodity markets pose serious challenges. Global integration of many agricultural supply chains is placing increasing control in the hands of large retailers, processors and exporters, whose compliance conditions are often difficult for smallholder farmers.

Interventions to encourage innovation depend on the initial context and how this changes over time. Interventions should not primarily focus on developing research capacity, but should be developed from the outset in a way that encourages interaction between public, private, NGO and civil society organisations. Key elements include: (i) Building and supporting partnerships; (ii) Strengthening of farmer organizations; (iii) Involving the private sector and ensuring use of market driven approaches; (iv) Improving access to information, knowledge and training; (v) Scaling up and adding value to country agricultural strategies; and (vi) Capacity strengthening in order to secure local ownership and sustainability.

Implications for integrated agricultural research for development

The case studies have shown that increased agricultural productivity is driven by the ready availabilities of new technologies together with improved incentives for farmers and agribusiness supported by enabling government policies. It is increasingly recognised that IAR4D and innovation systems approaches have a major role to play in introducing new ways of working. This requires facilitation to ensure working relationships and involve partners in alliances that will stimulate innovation. The implications for accelerating agricultural development in SSA include:

- An increased focus on the interface between research and the rest of the sector requires the creation of links in ways that encourage interaction between public, private, NGO and civil society organisations. This necessitates support for facilitation of engagement and alliances between partners that create the environment for innovation.

- Support to encourage institutional innovation with expertise that includes a wide knowledge of markets, agribusiness and rural finance that can complement specialist technical expertise."

Redefining national, regional and international roles in agricultural research

Petit, M.J. 1996. *The Emergence of a Global Agricultural Research System*. Washington, DC: World Bank.

"This report is the first intellectual product of the Agricultural Research and Extension Group (ESDAR) of the World Bank.[22] The theme of the report is the emergence of a global agricultural research system. It provides both an analysis of major changes occurring internationally, which demonstrates the major redistribution of roles and partners on that scene, and a call for more coordinated action among all

[22] ESDAR was dissolved in 1998 and its responsibilities were reassigned, mainly to the Agriculture and Rural Development Department of the World Bank.

agencies supporting agricultural research. The report also looks at the present role of ESDAR. A greater degree of coordination is possible because of a greater and clearer consensus than ever before on what needs to be done."

Chaparro, F. 1999."Towards a Global Agricultural Research System: A NARS Perspective." Paper presented at the European Forum on Agricultural Research for Development, Wageningen, 7-8 April 1999.

http://www.fao.org/docs/eims/upload/211000/Towards_Global_ARD-NARS_Perspective.pdf

This paper proposes that GFAR should concentrate its efforts on four priority areas: (i) The development of a shared vision to mobilize the world scientific community in their efforts to alleviate poverty, increase food security and conserve and manage natural resources; (ii) Strengthening NARS and the regional/sub-regional fora that have been established to foster/facilitate cooperation among them; (iii) Promote cost-effective research partnerships among the stakeholders of agricultural research and sustainable development; and (iv) Sharing of agricultural information and knowledge by taking full advantage of the opportunities created by the new information and communication technologies.

In order to focus and orient the activities that should be carried out in developing these four priority areas, the Global Forum is concentrating its attention in three themes, namely: (i) Development of new institutional and organizational approaches for ARD; (ii) Genetic Resources Management (GRM) and Biotechnology; and (iii) Natural Resources Management (NRM) and Agroecology.

McIntyre, B.D., H.R. Herren, J. Wakhungu and R.T. Watson, eds. 2009. *Agriculture at a Crossroads: International Assessment of Agricultural Knowledge, Science and Technology for Development*. Global Report. Washington, DC: IAASTD.

http://www.agassessment.org/reports/IAASTD/EN/Agriculture%20at%20a%20Crossroads_Global%20Report%20(English).pdf

This 600 page report is the final result of an International Assessment of Agricultural Science and Technology for Development (IAASTD), which was co-sponsored by various UN agencies and the World Bank. It was modelled after the International Panel on Climate Change (IPCC) and launched in 2004. IAASTD mobilized during the assessment a very wide range of participants from government agencies, private businesses, and civil society organizations. In addition to its central bureau at the World Bank, IAASTD collaborated with four implementing agencies (ACTS in Kenya, IICA in Costa Rica, ICARDA in Syria, and WorldFish in Malaysia) in order to have a more regional presence. More than 400 authors from around the world contributed to the final report.

However, at the end of the day, three countries (Australia, Canada and the USA) withheld their approval of the report as it was rather critical regarding GMOs and high-input agriculture. But also more generally, the report has received in most circles only lukewarm response. It perhaps tried to be too comprehensive. Despite the enormous effort (and resources) that went into the report, it is not being much cited. Nevertheless, it is a scholarly and well-documented report with a lot of useful information.

Lele, U., J. Pretty, E. Terry and E. Trigo. 2010. *Transforming Agricultural Research for Development.* Report for the Global Conference on Agricultural Research for Development (GCARD), 2010. Rome: GFAR Secretariat.

http://www.fao.org/docs/eims/upload//273759/GAT%20Report%20for%20GCARD%202010%20-%20Version%2011.0.pdf

This report was prepared for the first Global Conference on Agricultural Research for Development (GCARD) held in Montpellier (France), 28-31 March 2010. It summarizes the findings of various sub-studies, including a series of regional priority setting exercises.

"[The report stresses] that the developing world's agricultural research systems are currently insufficiently developmental-oriented. Research organizations have generally not been good at integrating the needs and priorities of the poor in the work of researchers. Farmers have difficulty accessing new technologies and innovations and many lack organized networks. There is a disconnection between research and extension systems as well as between researchers and policy makers. Many research systems are under-resourced, and even those that are well-endowed tend not to be sufficiently connected with the broader processes of development. These communications also stress that a change is needed in the incentive structures in the national and international research community to deliver impacts for the poor. They emphasize that systems need to be more accountable to their beneficiaries rather than focus on the outcomes of scientific achievements alone. They also note that there are few incentives for national and international research systems to work more closely with policy makers or with farmers' organizations, or to invest in coordination, knowledge management and communication. Their constituent institutions often have insufficient connection with, and accountability to, their desired beneficiaries." A transformation is needed of the currently very fragmented agricultural research system for development into a more cohesive one.

"Agricultural research systems must also become more agile and adaptable in responding to the fast changing external environment. In an age of globalization, the poorest are hit the hardest by external shocks as the food and the financial crisis of 2007 and 2008 have well-established. Integration of the global markets across sectors has occurred at a speed unanticipated by most. Climate change is projected to most affect the regions with the most poverty. Energy, climate change and market integration are likely to be important drivers of the future agendas for the poor, though others may add to this list. At the same time, cell phones and other technologies are making a revolution in the ability of the poor to access information transforming the ways in which they are or can be reached.

There are additional obstacles as well as opportunities that countries and regions will need to take into account. These are addressed in the main body of this report, and include:

- The poorest people tend to be women and children, who have even less voice than poor men but again through decentralization rapid changes are taking place in representing their interests.
- Our understanding of the microeconomics of households living in poverty is however weak at best and fragmented by sectors (e.g. agriculture, health, forestry) at most. It needs to be strengthened.
- National and regional organizations are coming into their own and yet have several weaknesses of their own including inadequate representation of women, civil society, the private sector and the environmental groups. They focus mainly on crops. They will need substantial strengthening to improve priorities and resolve differences on behalf of all stakeholders.
- Gender concerns are not always on the forefront of agricultural research systems in all developing regions but are strong in some developing countries and in the donor community at large.
- Civil society organizations are highly-developed in some parts of the developing world, and already have shown they can have substantial impacts on agricultural and rural policies and development in important ways. But these voices are still nascent in many part of the developing world.
- The lack of effective extension systems hinders the effectiveness of agricultural development that helps the poor and benefits the environment.
- Neither developing countries nor donors have kept their promises to meet targets on allocations of national budgets or of aid amounts to food and agriculture. On the other hand there are many

examples of misallocation of funds to areas of activity with limited if any benefits to the poor. Overall official aid as well as it share to agriculture and infrastructure has been declining. In some regions of the world, net aid flows are already negative and even in those regions with the largest number of poor overall aid and shares to agriculture and infrastructure have declined.

- More aid goes to emergencies than for long-term agricultural or rural development.
- Political obstacles to cooperation *in all parts of the world* are vital because they entail vested interests and competition for scarce resources, whether for energy, water, finances or institutional reforms.
- Resistance to policy and institutional reforms tends to be great even in the face of a fast changing reality which calls for change.
- And yet if TAR4D focused only on poverty reduction it will cover only subsectors of two parts of the developing world where poverty is concentrated. The focus on poverty is necessary and urgent but not sufficient either for a GCARD or for achieving impacts on reducing poverty. It will systematically overlook the opportunities to borrow ideas, technologies and approaches from other sectors and other parts of the world.
- Emerging countries are becoming powerhouses.
- Science and technology are advancing at remarkable speed.
- Emerging economies and some developed countries and their regional groupings, e.g. EU, have expressed enthusiasm to mobilize their expertise for global cooperation under a new GCARD umbrella.
- The global and regional *institutional capacities*, including that of GFAR, to harness these tremendous new opportunities remain low at present. They can, though, be built.
- All regions are demanding and must have an opportunity to benefit from these possibilities.

These are no minor threats or obstacles but also huge opportunities. They offer all the reasons why significant steps need to be taken now if a true Transformed Global Agricultural Research for Development System is to evolve. Even at best it will take more time to achieve than the changes in the environment require. It means mobilizing, reorienting, strengthening and bringing coherence to a currently fragmented system to help the poor escape poverty until they can effectively participate in the overall agricultural and economic growth processes underway elsewhere in their countries and in the world."

"Currently many countries are experiencing downward pressure on economies. Nevertheless this calls for increased investments in agricultural research, extension and development. Barring China, Brazil and India, most countries have neglected to invest in their agriculture and even those systems acknowledge that they face challenges in addressing issues of the environment and poverty. Given the time lags of 7 to 20 years from research to impact in the field, increased funding *to agricultural research to 1 % or 1.5 % of agricultural GDP* is certain to be a recommendation for GCARD 1 and should be systematically monitored and outcomes disseminated.

A substantial amount of this investment must go into human capacity building and to modernize research management and incentive systems for researchers in order to increase their relevance and accountability to the poor clients.

Many can learn from the experiences of emerging economies and OECD countries and GFAR should have an active role in fostering such cross learning and good practice.

It is impractical to set investment targets for overall agricultural development at GCARD 1; Sub-Saharan African countries have adopted the target levels of investment but have not met them. In other cases investment has been misallocated and requirements vary depending on the resource base and most governments have not followed through on their promises. Yet there is need for massive reforms and

investments to improve delivery conditions and systems including the need for secure land rights, seed and credit, revival of extension systems, engagement of CSOs, development of policy capacity, promotion of rural infrastructure and information technology, and establishment of appropriate financial institutions and increased attention in measuring and tracking performance and accountability. All require attention and investments estimated by FAO to be in the billions of dollars.

Avoiding paralysis by further analysis is not an option. Moving to concrete actions with each individual and entity taking responsibility is the only option. The Global Conference on Agricultural Research for Development 2010, the first in a series of biennial global conferences, is designed *to initiate* and report progress on this transformation. Successive cycles of collective action will determine if rapid cross-learning and progress is taking place and if more transparent mutual accountability among all stakeholders is developing.

In summary, the Global Author Team of GFAR to the GCARD ***acknowledges*** the substantial contribution of agricultural research leaders and institutions to development, ***recognizes*** their role in the removal of persistent food poverty of many rural and urban people across both developing and developed countries, ***notes*** the unpredictable global economic environment resulting from rapid global integration which most affects the poor, ***accepts*** the emergent and uncertain challenges of climate change and related pressures on environmental services, ***argues*** that agricultural research for development must be transformed, ***calls*** for more financial investment to foster rapid and broad-based innovation, and ***sets out*** a road map for the immediate future."

GFAR. 2011. *The GCARD Road Map: Transforming Agricultural Research for Development Systems for Global Impact.* Rome: GFAR Secretariat, FAO.

http://www.fao.org/docs/eims/upload//294891/GCARD%20Road%20Map.pdf

A draft version of this roadmap was already included in the Lele et al (2010) report (see above), but this is an updated and improved version of the roadmap completed after the conference.

"The global fragmentation and under-resourcing of public innovation, education and advisory processes and weak linkages with wider development processes and with farmers, NGOs and the private sector, are major bottlenecks constraining the value and impact of agricultural innovation on the lives and livelihoods of the poor.

The GCARD Roadmap highlights the urgent changes required in Agricultural Research for Development (AR4D) systems globally, in order to address worldwide goals of reducing hunger and poverty, creating opportunity for income growth while ensuring environmental sustainability and particularly meeting the needs of resource-poor farmers and consumers.

The GCARD Roadmap establishes an inclusive, rolling process of reform and capacity development that aims to mobilize the full power of agricultural knowledge and innovation towards meeting agriculture and food-related development needs. It proposes a six-point plan for transforming agricultural research for development around the world, requiring actions from all those involved in the generation, access and use of agricultural knowledge**:**

1. The need for collective focus on key priorities, as determined and shaped by science and society;
2. The need for true and effective partnership between research and those it serves;
3. Increased investments to meet the huge challenges ahead and ensure the required development returns from AR4D;
4. Greater capacities to generate, share and make use of agricultural knowledge for development change among all actors;

5. Effective linkages that embed research in the wider development context and actions enabling developmental change; and
6. Better demonstration and awareness of the development impact and returns from agricultural innovation."

The GCARD Road Map describes for each of the six points their 'strategic elements' (i.e., defining the actions needed), "required roles at the national, regional and global level" and "desired outcomes and milestones".

Roseboom, J. 2011. "Supranational Collaboration in Agricultural Research in sub-Saharan Africa." Conference Working Paper No.5 prepared for the ASTI/IFPRI-FARA Conference Agricultural R&D: Investing in Africa's Future. Accra, Ghana, 5-7 December 2011.

http://www.asti.cgiar.org/pdf/conference/Theme4/Roseboom.pdf

"This paper focuses on how supranational collaboration in agricultural research in Sub-Saharan Africa has evolved over the past 10 years. It focuses primarily on the various institutional developments, but also presents some quantitative data on investments in the Forum for Agricultural Research in Africa (FARA), the sub-regional organizations (SROs), and the Consultative Group on International Agricultural Research (CGIAR). Institutional reforms introduced in recent years (such as a programmatic approach at the SRO level, multi-donor trust funds, competitive grant mechanisms, and centers of excellence) are reviewed and assessed, and suggestions are made for further improvements. The principal conclusion is that the overall institutional architecture for supranational collaboration in agricultural research is now almost in place and that for the coming years the focus should be more on mastering and further fine tuning of the various internal decision-making and implementation processes. One of the more crucial issues is how to identify and implement a truly supranational research agenda (i.e., one with large spillover effects / cost savings). At present, a lot of the regional funding is leaking away towards research activities that are essentially local. Moreover, despite all efforts to increase African ownership of the supranational agricultural research agenda, high donor dependency remains a factor that limits such ownership. The only way to change this is by introducing an African funding base for supranational agricultural research. Unfortunately very little progress has been made on this front to date."

Global Forum on Agricultural Research (GFAR)

Website: www.egfar.org

GFAR was formally established in 1996 and initially comprised two secretariats, namely the GFAR Secretariat based in the World Bank in Washington DC dealing mainly with donors and multilateral agencies and the NARS Secretariat based at FAO in Rome dealing with NARS. In 2000, these two secretariats were merged into a single GFAR secretariat operating from FAO Headquarters in Rome.

GFAR aims to bring together all actors in agricultural research around the world in order to strengthen and optimize linkages between the different actors. GFAR is also responsible for organizing, together with the CGIAR, the bi-annual Global Conference of Agricultural Research for Development (GCARD). The first such a meeting took place in Montpellier, France (28-31 March 2010) and the second in Punta del Este, Uruguay (29 October to 2 November 2012). The first meeting resulted in a GCARD roadmap (i.e., defining what type of transformation of agricultural research for development is required and how this affects the different roles of actors within the global research system), while this second meeting focused in particular on how to implement the GCARD roadmap in practice and the difference it makes.

In the past, the annual meetings of the CGIAR tended to function as the place to discuss global collaboration in agricultural research. This role has now been shifted to GCARD, which gives other actors (in particular the regional agricultural research networks and NARS) a more prominent place.

Consultative Group on International Agricultural Research (CGIAR)

Website: www.cgiar.org

Consultative Group on International Agricultural Research (CGIAR) started off in 1971 as an *informal* grouping of donors and international agricultural research centers focusing on agricultural problems in developing countries. In 2008, a major restructuring of the CGIAR took place, transforming it from an 'informal grouping' to a more cohesive and tighter managed consortium, consisting of two pillars:

- The CGIAR Consortium, which integrates the research conducted by the 15 Consortium members. The CGIAR Consortium is made up of: (i) The Consortium Board; (ii) The Consortium Chief Executive Officer and Consortium Office; and (iii) Research Centers which are members of the CGIAR Consortium.

- The CGIAR Fund, which is a multi-donor trust fund that finances CGIAR research activities. Its funding is guided by a CGIAR Strategy and Results-Based Framework.

In addition, the CGIAR comprises two independent support units, namely: (i) The Independent Science and Partnership Council; and (ii) The Independent Evaluation Arrangement.

In 2011, total revenues of the CGIAR reached US$ 735 million and total staffing reached 8784 (of which 1373 international positions and 7411 local positions).

Chapter 7. Re-thinking NARS capacity building

Asopa, V.N. and G. Beye. 1997. *Management of Agricultural Research: A Training Manual*. Rome: FAO.

http://www.fao.org/docrep/W7500E/w7500e00.htm#Contents [Each of the modules has its own pdf.]

This is a training manual on agricultural research management compiled and published by FAO. It is based, among other things, on many of the ISNAR materials.

ISNAR. 1999. *A Selection of Training Modules on Agricultural Research Management*. The Hague: ISNAR.

ftp://ftp.cgiar.org/isnar/Training/PDF/Trcat-99.pdf

This publication is just an overview of all the different training modules that ISNAR had developed up to 1999. The modules themselves are stored in the archive folder: ftp://ftp.cgiar.org/isnar/Training/

Lele, U. and A.A. Goldsmith. 1989. "The Development of National Agricultural Research Capacity: India's Experience with the Rockefeller Foundation." *Economic Development and Cultural Change* Vol. 37, No. 2 305-343.

http://www.umalele.org/images/stories/documents/the_development_of_national_agricultural_research_capacity_india_s_experience_with_the_rockefeller_foundation_and_its_signif.pdf

"The donor community's growing interest in building country-based agricultural research capacity in Africa is encouraging. Less hopeful is the fact that many of the preconditions for technological chance

that existed in India in the 1950s are absent in Africa in the 1980s. To begin with, the continent's agricultural research problems are far more diverse, its climate more varied, its pests and disease hazards more pronounced, its farming systems more complex.

The magnitude of these scientific and technical problems is out of all proportion to the limited scale of the indigenous human and financial resources that individual African countries are able to devote to their solution; and these resource limitations in turn militate against scale economies in agricultural research and technical assistance. At the same time, the superficially attractive alternative of creating regional agricultural institutions for Africa has been hampered by institutional rivalries and domestic political instability. In any event, such institutions cannot—by their nature—substitute for the kinds of well-funded national systems that are needed to deal with the enormous inter-country (and intra-country) variations in African agriculture.

The Indian case, nevertheless, suggests five broad lessons for improving the odds for successful research in Africa. The first is that political will at the highest level is required to build effective science and technology capacity and (as in India) that severe external shocks are more conducive than tranquil times in facilitating the resolution of many controversial questions associated with institutional innovation and technology transfer. The droughts, global economic trends, and donor disenchantment of the 1970s and early 1980s have already resulted in a sharpened awareness of Africa's problems. This is a necessary but not a sufficient condition for technological innovation, and many of the kinds of decisions that India made in the mid-1960s in order to build its research system remain to be made by African countries.

Second, African countries and donors need to adopt a holistic approach to developing national research capacity, by achieving a better interaction and balance between the development of scientific manpower and the provision of physical capital (which usually takes precedence in donor financing of research). Another prerequisite for success is better integration of the planning of research efforts and assuming responsibility for their implementation. While current agricultural research projects designed by ISNAR and funded by the World Bank are more comprehensive in theory, in practice donors tend to divide up the 'pie' among planners and implementers as well as by crops, regions, stations, scientific disciplines, or subject matter – thus making it impossible to develop a coordinated research program.

Third, donors need to reduce the noise of competing projects and research designs. While it may not be possible in Africa to achieve the homogenous advice supplied by American organizations in India, more interagency coordination is certainly essential. This requires untying technical aid to ensure that assistance is forthcoming from both the most qualified and the most cost-effective sources. Also, the CGIAR system needs to develop the capacity to help developing countries select the most competent bids and to assure that they can pick from among unified teams of technical assistance experts. This may frequently involve choosing proposals that keep physical equipment to an absolute minimum in the initial stages of research development.

The fourth general lesson is the need for long-term commitment of personnel—both by African governments of their own nationals in key technocratic positions and by donor agencies of expatriate counterparts. Too often inexperienced or short-service technical assistance personnel are expected to work with middle-level technocrats to develop new institutions. The CGIAR and governments need to devote greater attention to long-term career opportunities for seconded personnel to maximize the institutional effectiveness of their work.

This raised the fifth, and perhaps the most important lesson. It is fundamental for African elites to recognize the long gestation lags involved in the creation of national scientific capacity in agriculture. In India, a decade of cooperation between the same Indian and American officials eventually made it possible to focus national political energy on improving capacity. Only a similar long-term commitment by African policymakers can hope to promote and sustain appropriate research institutions in the unique

environment of Africa. African future development will depend critically on scientific advances in agriculture adapted to African conditions. ”

IAC. 2004. *Realizing the Promise and Potential of African Agriculture: Science and Technology Strategies for Improving Agricultural Productivity and Food Security in Africa*. Amsterdam, Netherlands: InterAcademy Council (IAC).

http://www.interacademycouncil.net/24026/AfricanAgriculture.aspx

This report by the Inter Academy Council (a multinational organization bringing the expertise together from Science Academies around the globe) takes a stab at setting out a comprehensive agricultural science and technology agenda for Africa. In addition to chapters analysing Africa’s agricultural production challenges and S&T opportunities, it also comprises two chapters dealing with ‘institutions’ and ‘human capital’. The main recommendations of these two chapters are cited here.

“The IAC Panel recommends the following actions for building impact-oriented research, knowledge and development institutions:

- *Design (and invest in) national agricultural science systems that involve farmers in education, research and extension*. Instead of the outmoded linear and top-down research-extension-farmer framework that has failed in Africa, design new innovation, information, knowledge and education systems – with new information and communications technologies playing a central role. Start from the bottom up in developing rural knowledge-based systems using participatory models.
- *Encourage institutions to articulate science and technology strategies and policies*. To maximize the benefits and achieve true food security, a coordinated strategy is needed that includes not only agriculture, but also health, education, and rural planning and development. There is a special need to recognize the key role of women’s education and status in reducing child malnutrition – the most insidious form of malnutrition so prevalent in Africa.
- *Increase support for agricultural research and development*. Africa’s agricultural science community cannot flourish if it continues to depend upon foreign aid for approximately 40 percent of its budget. Governments as well as donor agencies must recognize that building impact-oriented institutions requires sustained and sizable increases in the support of agricultural research and development. To decrease the dependency on foreign aid, more investment is needed by Africa itself. Agricultural research funding in Africa should increase in real terms by at least 10 percent per year to 2015. This would double the agricultural research investment on average to at least 1.5 percent of agricultural GDP in African nations.
- *Cultivate African centres of agricultural research excellence*. These centres should be designed to enable research on both continental and regional priorities as a complement to the national agricultural systems. By using modern communication technologies to network with other institutions with complementary skills and goals, each centre will become a virtual centre for particular research areas. Each would be African owned and governed, thereby providing a magnet for African scientists to remain at home, as they work to strengthen African national agricultural research systems.
- *Strengthen international agricultural research centres*. International agricultural research centres with headquarters and programs in Africa should retain their international identities. They should, however, operate in more collaborative and complementary modes with national agricultural research institutes and universities, and in participatory partnerships with both farmers and consumers. The level of investment in the CGIAR African centre programs for research and capacity building should be increased by 5 per cent per year, to at least US$235 million by 2015.”

"The IAC Panel recommends the following actions for creating and retaining a new generation of agricultural scientists:

- *Broaden and deepen political support for agricultural science*. Real improvement in agricultural education and research requires strong support from top political leaders. A coalition of supportive agricultural constituencies must be formed, including farmers associations, producer groups, national agribusiness companies, educators and researchers.
- *Mobilize increased and sustainable funding for higher education in science and technology, minimizing dependence on donor support*. There is an urgent need for an increase in both the numbers of students and the quality of their agricultural education (e.g., science, food processing, natural resource management, and rural development) at primary, secondary and tertiary levels. At the tertiary level, the 'sandwich model' provides an effective tool for building capacity while maintaining a focus on African needs. This model educational approach allows university students in developing nations to spend one year at a university in an advanced S&T nation, then return to their home universities for completion of their degree programs.
- *Focus on current and future generations of agricultural scientists*. A greater effort must be made to retain current and future generations of African scientists to reduce the brain drain. This requires the implementation of policies that create personally and professionally rewarding scientific opportunities in Africa. Such policies must include merit-based selections and promotions, competitive compensation, well-equipped laboratories, access to global sources of scientific information, and adequate operating funds.
- *Reform university curricula*. The undergraduate curricula of agricultural universities should stress production ecological and multi-disciplinary approaches to better prepare scientists for the new innovation, information, knowledge and education systems. Students should be directly exposed to farmers' needs and to quality agricultural research and extension (completing the synergistic 'quadrangle' recommended in this report). They should also become better sensitized to the socio-economic and policy environments in which agricultural development occurs and in which they will be working during their careers.
- *Strengthen science education at primary and secondary school levels*. A special emphasis must be placed on improving the accessibility and friendliness of science training to young women. Farm science schools where the pedagogic methodology is 'learning by doing' are urgently needed for the knowledge and skill empowerment of farmers."

Gordon, J. and K. Chadwick. 2007. Impact Assessment of Capacity Building and Training: Assessment Framework and Two Case Studies. Impact Assessment Series. Canberra: ACIAR.

http://impact.cgiar.org/pdf/76.pdf

"There is wide recognition that capacity building and training are prerequisites to economic and social development (World Bank 2006a), and the development community is estimated to spend US$15 billion per year on capacity development (World Bank 2006b). Nevertheless, most evaluations of capacity building stop well short of attributing benefits to training, mainly going only so far as to claim that the capacity building made a significant contribution to achieving project objectives.

This study was motivated by the lack of evidence to support the strongly held convictions that improving human capacity is inherently valuable and absolutely necessary for the achievement of development objectives.

ACIAR and the Crawford Fund capacity building

The Crawford Fund provides formal and informal training for researchers, agricultural department staff and farmers in developing countries. The Australian Centre for International Agricultural Research

(ACIAR) incorporates formal training and learning-by-doing in most of its agricultural research projects, as well as supporting a scholarship program for research scientists.

Pathways from capacity building to impacts

Capacity-building activities contribute to improved economic, environmental and social outcomes through four main pathways:

1. Individual human capital raises the productivity and hence the earning capacity of the individual, reflected in higher lifetime income;
2. The efficiency of the organization as it captures part of the returns from the individual improvement in productivity, and due to the echo effect improving the productivity of other workers via complementarity—for example, extension of their learning and adding to the local stock of knowledge. This is reflected in improved levels and/or reduced cost of services or outputs delivered by the organization to customers;
3. Innovation in the organization as the culture and mindset changes, new and better ways of doing things are introduced and new products and services are developed. This is reflected in the changes in the services or outputs the organization delivers to customers; and
4. Effectiveness of the organization within the policy environment, improving targeting to areas of need, attracting more resources and engaging more effectively on policy, due to the networks and enhanced perceptions of the views of the organization, as well as its competency. This is reflected in the contribution the organization makes to the enabling environment for adoption of the organization's outputs and enhances the value added of the organization.

These 'changes in practice or behavior' reflect capacity used by the individual and the organization they work for. The potential to utilize capacity depends in part on the capacity that has been built by the training activities. This depends, in turn, on the relevance and quality of the training or other capacity-building activity provided, as well as the degree to which the organization uses the skills, knowledge, networks and other capacity developed by the activities.

The ultimate beneficiaries, apart from individuals who may receive both financial and intrinsic benefits from the training, are the customers of the organizations. For agricultural research and development (R&D) these customers are primarily the farmers and communities in which they live. Thus, impact is ultimately derived through the delivery of lower-cost and/or better-quality goods and services. Impact can also come through a better enabling environment that enhances farmers' access to resources and markets and allows them to reap the rewards of their own labor.

A framework for evaluating capacity-building activities

The methodology outlined here was developed following an extensive review of the literature on capacity-building evaluation and the impact of educational training. This review found that most evaluation approaches do not measure impact, citing attribution as a key challenge.

The framework described aims to elucidate and substantiate the linkages between the training provided and the intended or observed benefits, thus facilitating the attribution of benefits to specific capacity-building investments.

Mapping to impact. Three types of capacity-building situations are identified, with different implications for the evaluation approach, namely:

1. Gap filling—where the activity fills a gap that enables progress to be made towards a broader set of outputs and outcomes. In this case the capacity built may be sufficient to result in a change in practice or behavior at the organizational level (as set out above).

2. Integrated—where the training activities are identified as a component in a broader set of technical or other investments. In this case, the capacity-building activity is usually necessary but not by itself sufficient for the desired change in practice or behavior.
3. Diffuse—where the training activity adds to the stock of human resources but cannot be linked directly with specific change in practice or behavior. In this case, it is the quantum of capacity built that leads, over time, to changes rather than any one contribution to this capacity.

Measuring impact and benefit. The value of the capacity building depends on the value of the impact resulting from the change in practice and behavior of organizations. In the case of agricultural R&D, these changes are often:

- New varieties of plants or breeds of animal with specific genetic characteristics that endow them with greater range, higher yields or disease resistance;
- Better management practices that are more sustainable, resilient, improve yields or lower costs of production;
- Lower costs of production, transport and marketing due to improvements in the business, regulatory or policy environment resulting from better informed decision-making;
- Improved food safety or other quality assurances that reduce consumption risks to households, attract premiums or facilitate market access; and
- More-effective supply-chain management, such as cold-chain integrity, reduced time to market and wider distribution options.

In estimating the impact, the adoption profile and the transferability of trial results to practice must be known. These will depend on the relevance of the outputs to farmers in different regions (or, for policy changes, the regulators) and implementation costs, as well as the farmers' awareness of the option and their capacity to exercise it. The estimation of the benefits arising from these impacts follows normal benefit–cost rules.

Attribution. Once the benefits are estimated, the issue is the share of the benefits that can be attributed to the capacity building activity. Three broad scenarios have emerged, based on whether the capacity built is sufficient, or necessary but not sufficient, or would have otherwise been achieved over time (or an alternative that would achieve the change in practice or behavior found). The framework outlines five approaches to attribution and the scenarios under which they are applicable.

Where capacity building is necessary but not sufficient:

1. The cost-share approach apportions the share of the benefits (net of implementation costs) to capacity building based on the share of the expenditure going to the capacity-building activities.
2. The relative-importance approach apportions the share of benefits on the basis of a subjective assessment (triangulated) of the contribution (percentage) of the capacity-building activity to the outputs achieved. This can be used if the training would have been sufficient to get some but not all of the outputs, with an assessment made of how much. It can also be used when the training is necessary but not sufficient, but a strong case must be made as to why the training components were worth more than the other components.

Where capacity building is neither necessary nor sufficient, but improves outcomes:

3. The bring-forward approach is used where the changes would have come about through normal processes, but the investment in capacity building brought forward the changes and hence the impact. The focus of measurement is on the time to impact without the capacity-building activities, compared to the time with.

4. The marginal-gain approach is similar to the bring-forward approach, but applies when the investment in capacity building raised the quality of the changes and hence the magnitude of the impact. The focus of measurement is on the effect that higher quality has on the size of the impact.

Where capacity building alone, given the context, is sufficient:

5. Normal impact assessment should be undertaken, with full attribution to the capacity-building activity. Where this activity filled a gap that was critical to achieving the outcome, and without the activity would not otherwise have been filled, the other investments can be regarded as sunk costs.

The returns to capacity building tend to be highest where training or other capacity building is critical to achieving a change. However, care must be taken not to ignore other investments when it has always been recognized that the capacity-building activity is needed. The impact of a capacity-building activity is the same no matter who funds it. Thus, the argument that someone else would have funded it does not devalue the impact of the activity. It does, however, require caution in treating other investments as sunk costs.

Rules of thumb

Several rules of thumb about the return on training also emerged:

- a worker's lifetime income is higher, on average, by around 10% for each additional year spent in formal education
- the firm captures around half of the benefits of their investment in specific training for their workers,
- the workers capturing the other half, and the individuals trained around a third
- improvements in human capital explain around 30% of the increase in total factor productivity
- 50% of increases in (agricultural) productivity are due to interstate or international R&D spillovers.

The method was applied to two case studies that demonstrated the value of the capacity-building activities in an integrated context, with the following findings.

- A 3-year postdoctoral fellowship, funded by ACIAR as an integral component of their pigeon pea improvement projects and undertaken in Australia by a plant scientist from ICRISAT, India, resulted in estimated benefits of A$70 million at an estimated cost of A$2.5 million. This evaluation was based on the relative importance of the training activity to achieving the project impacts and expert opinion about the number of years the ACIAR projects brought forward the adoption of improved pigeon pea genotypes.
- A 3-week intensive geographic information systems (GIS) capacity-building exercise, funded by a Crawford Fund award and undertaken in Australia by a Vietnamese GIS specialist, provided estimated benefits of A$82,837 at an estimated cost of A$6,723. This evaluation was based on the cost-share approach because the GIS training was regarded as a vital ingredient in achieving the project impacts of more efficient water usage in irrigation systems. The trainee's enhanced GIS skills enabled the creation of site-specific water management models that played a crucial role in demonstrating to the irrigation companies the benefits of adopting improved operational rules for water management."

Global Donor Platform for Rural Development (GDPRD). 2012. *Donor Methods to Prioritize Investments in Agricultural Research and Development.* Synthesis Paper. Bonn, Germany: GDPRD Secretariat.

www.donorplatform.org

"One objective of the agriculture research for development working group of the Global Donor Platform for Rural Development (Platform) is to improve knowledge of and harmonize donor methods to prioritize investments in agricultural research and development.

This report describes: (i) The context in which investments are selected in agricultural research; (ii) Reviews methods for agricultural research prioritization; (iii) Describes mechanisms donors use to program agricultural research resources; and (iv) Suggests how donors might adjust their prioritization strategies to improve coordination and potentially increase impacts of their portfolios.

The decision to fund agricultural research versus other interventions can be guided by: (i) The need to evaluate donor investments in terms of their expected contributions to goals; (ii) The comparative advantage of agricultural research compared to other interventions; (iii) The order of the decision process; (iv) The complementarity of investments; (v) Differences in the time periods for investments; and (vi) The riskiness of investments.

Review of agricultural research priority setting methods

Agricultural research priority setting by donors involves: (i) Identifying and prioritizing donor goals; (ii) Defining the research alternatives to be prioritized; (iii) Projecting impacts or contributions (to donor goals) of research on the alternatives—considering the degree of risk and uncertainty associated with the impacts; and (iv) Comparing the alternatives and establishing priorities once impacts are estimated (projected).

These four elements are included in research priority setting regardless of specific methods employed – although donors differ in the way they address them.

Goals

An array of donor goals is used in agricultural research priority setting. Agricultural research can be expected to contribute to some goals more than others and differs in its ability to achieve them as compared to the ability of other interventions. Meeting the goal of improved productivity, income and food security also contributes to other goals such as improved nutrition and health or sustainability of the natural resource base.

Research alternatives

Opinions of key stakeholders are important in defining the appropriate researchable alternatives. Information on what is possible to achieve through research should draw on appropriate, often multidisciplinary, scientific expertise. A participatory structured process that identifies key researchable problems and the potential contributions of different disciplines to them is essential.

Impact assessment

A key part of research prioritization is projecting the impacts that can be achieved through investment in different types of research. Quantitative assessments are preferred where confidence can be placed in the results, but the level of confidence differs depending on the nature of the research and the types of impacts. In some cases donor research budgets are largely aimed at strengthening national and

international research institutions. Improvements in productivity or efficiency are among the easiest impacts to project quantitatively. Methods for projecting agricultural research impacts on nutritional and human health wellbeing and on the natural resource environment are also available, but due to the multifaceted nature of nutrition, health and the environment, less confidence can be placed in the results.

Impact assessment can absorb significant resources—so choices must be made on the level of rigor and resources to devote to assessing potential impacts of alternative research themes. For each donor goal, a few key factors determine the expected contributions of a research project toward achieving the goal. For the goal of improving agricultural productivity, income growth and food security, key factors include the current value of production, projected impacts of the research on yields and costs, the odds of success in the research, the likely adoption of the technologies and the timing of the benefits to be received. For the nutrition/health goal, the size of the target group, the incidence of the problem, the mortality rate or degree of disability associated with the problem deficiency and the projected effects of the research on reducing the problem drive research benefits.

The impact of research on quantities produced and consumed and on prices paid affect nutrient consumption. Thus an economic assessment can also be a starting point for a health/nutrition assessment—the foods that make up the largest portion of the consumption of malnourished people are those that also may have the biggest impact on nutrition

Key factors influencing poverty effects of research are: (i) The number of poor; (ii) The depth of their poverty; (iii) The income provided by the research results or technology; (iv) The adoption of the technology by the poor; and (v) Food price changes affecting consumers.

The environment is multidimensional but a practical method for assessing environmental sustainability is to assess the physical effects of the research on specific environmental categories. Availability of data to support environmental impact assessment varies by category of environmental impact and the data are often rough.

Donors must consider the extent to which the research should be a public rather than a private responsibility. Another factor is the extent to which other donors are supporting research on a topic and the comparative advantage of the donor on the research themes.

Comparing alternatives

Tradeoffs must be considered with respect to research contributions to different objectives. The potential impacts of a research portfolio that emphasizes one objective versus another can be assessed and then how much the contribution of the portfolio to one objective would be reduced if the other objective is emphasized to differing degrees. To address the benefits of specific research options under varying levels of funding, research benefits can be projected under a high, medium and low level of funding for each alternative. Research that is already in the pipeline must be compared to new research.

Donor consultations

Informal consultations were held with representatives from seven donor organisations to discuss their current priority setting mechanisms. Representatives were interviewed from BMZ, GIZ, CIDA, DFID, EC, OECD, USAID and the Gates Foundation. Most donors reported using informal processes to set priorities because they lacked capacity, resources, or staff time to conduct formal, technical priority setting exercises. Some donors have at times engaged in formal priority setting but not on a regular basis. Donors indicated that the provision of reliable evidence was their most important criterion in evaluating priority setting mechanisms. Several interviewees hinted that easier to-use methods might lead to more widespread formal priority setting.

Donors had a favorable impression of analytical methods but none use them on a regular basis. Some stated that increased sharing of experience among donors and formal collaboration with other donors might improve their ability to utilize these methods. Few have in-house capability to conduct the exercises. Some were concerned that the evidence base—in favor of agricultural research—was weak for non-efficiency objectives. They felt that much of the academic priority setting literature focused too closely on efficiency, while many politicians currently favored non-efficiency objectives. They are concerned about tradeoffs between objectives and would like means of evaluating these tradeoffs when setting research priorities.

Mechanisms for investments in agricultural research

Donors engage a variety of institutions to conduct agricultural research for development, including the CGIAR system, universities, government agencies, NGOs, private research organizations and others. While the distribution of resources among institution type varies from donor to donor, it is clear that the bulk of research resources pass through the CGIAR system.

Reasons for this dependence on the CG include: (i) Confidence in the quality and relevance of CG-led research; (ii) Close correspondence between CG goals and donor goals; (iii) The ability of CG centers and CRPs to link with other actors including NARS and university researchers; and (iv) The ease of contracting with the CG and its ability to conduct large-scale, multidisciplinary research.

Donors are also increasingly partnering with applied research entities who can deliver research results to end users

Recommendations

Most donors employ informal, semi-structured processes to set agricultural research priorities and lack capacity, resources or time to conduct formal, technical priority setting exercises. However, the following recommendations may help improve the priority setting process.

Recommendation 1 – Systematize the prioritization process

A five-step sequence of practices can be useful for setting priorities for most donors: (i) Identify goals; (ii) Specify potential alternatives (topics or institutions) to be prioritized; (iii) Project contributions of research topics (institutions) to the goals; (iv) Consider tradeoffs associated with alternative priorities; and (v) Compare priorities to the current portfolio of topics or institutional investments and vet any changes against political acceptability

Projecting contributions of research to specific goals can be accomplished by applying a subset of impact assessment tools, can make use of the results from meta-analyses of previous research on the topics, or can make use of indicators or theory. A formal prioritization process is not completed each year, but should be undertaken when a new strategic plan is developed or at least every five years. Adjustments to priorities can be made more frequently and targeted impact assessments can be undertaken to inform those changes.

Recommendation 2—Contract with appropriate groups to project impacts

Most donors lack the internal capacity to directly apply quantitative priority setting tools. However, donors could individually, or acting as a group, contract with certain research groups to apply the tools and supply analyses of estimated impacts. Some impact assessment groups already have models and some of the data.

Recommendation 3—Insist the CGIAR do more priority setting

Because so many donor resources are directed at the CG system, donors might insist that the CG system do a more formal prioritization itself of proposed research topics. This prioritization process might be led by the Standing Panel on Impact Assessment (SPIA) and SPIA could contract out as well with appropriate groups as necessary.

Recommendation 4—Make use of accepted theory and available information

Even without quantitative tools, donor priority setting processes could make additional use of available information and theory. Income and productivity effects of research are driven to a large extent by: (i) Base value of production associated with a commodity; (ii) Expected per unit cost and yield changes if the research is successful; (iii) The likelihood of research success; and (iv) Projected adoption rate of the results and their timing.

Poverty is highly geographic and for producers affected by the value of the products produced and by the risk. The urban poor are affected significantly by the price of the food products they consume most. Poor women especially are affected by low food prices. Improvement in one goal can mean sacrifice in another and the tradeoff can be quantified if quantitative tools are used when evaluating impacts, or at least discussed if only qualitative methods are used.

Recommendation 5—Use quantitative tools where practical and credible

For the goal of improving agricultural productivity, income growth and food security, economic surplus and benefit cost analyses are time-tested methods that can be combined with other methods to provide donors with projected benefits and tradeoffs. Application of these tools can be externally contracted for during priority setting exercises. For the nutrition/health goal, the size of the target group, the incidence of the problem in the group, the mortality rate or degree of disability associated with the problem deficiency in each group and the projected effects of the research on reducing the problem are key factors determining research benefits.

Key factors influencing poverty effects of research on producers are the number of poor, the depth of their poverty, the income provided by the research results or technology and the adoption of the technology by the poor. Factors affecting poverty effects on consumers are the relative importance of the commodity in question in the expenditures of the poor and the expected fall in market prices due to the research. For assessing environmental sustainability, rely heavily on projected physical effects of the research across specific environmental categories. For major environmental topics such as climate change, information from global models can be used to predict the location of heat stress, flooding and other effects.

Recommendation 6—Ensure that priority setting methods help lead to tangible results in farmers' fields

To ensure that priority setting methods lead to result in farmers' fields: (i) Donors can fund a mix of long- and short-term research—so that short-term impacts can be realized without sacrificing long-term gains; (ii) Coordinate with in-country offices as they prefer to support technology transfer programs rather than research programs; (iii) Obtain input from field offices, NARS, NGOs and other local experts to identify the most pressing researchable problems; (iv) Insist that research groups funded have a plan for diffusing results; and (v)Include social scientists in research programs who study constraints to adoption."

Moock, J.L. 2011. "Network Innovations: Building the Next Generation of Agricultural Scientists in Africa." Conference Working Paper No. 1. Paper prepared for the ASTI/IFPRI and FARA Conference Agricultural R&D: Investing in Africa's Future, held December 5-7, 2011 in Accra, Ghana.

http://www.asti.cgiar.org/pdf/conference/Theme2/Moock.pdf

"Despite several decades of crises in agricultural higher education, there has been major improvement. Many universities and research institutes in Africa are abandoning outmoded ways of doing things and devising new structures, behaviors, and incentives. Yet these advances are often inadequate to produce a new generation of scientists and leaders with the knowledge and skills to replace the large numbers in the agricultural sector now close to retirement, and spur the agricultural growth needed to reduce poverty. One increasingly popular way of building a strong human capital development infrastructure and harnessing gains from innovation in the research process is investment in networks. Networks, for the purposes of this discussion, refer to postgraduate training and collaborations that strengthen institutions, unimpeded by geography—such as a collection of agricultural scientists capitalizing on greatly improved mobility and telecommunications to transcend institutional and national boundaries. This paper identifies five models of strategic networks making progress toward the stated goals of bolstering university-based training and research, and enhancing the productivity of the agricultural sector. These models, while different in their composition, offer key principles and approaches of networks that are scalable and have the potential to be sustained. Of particular importance are those with the ability to produce "scientist entrepreneurs," create professional career structures, ensure gender equity, build economies of scale and serve as leverage points for translating knowledge into innovation and application."

DFID. 2010. *How to Note on Capacity Building in Research*. A DFID Practice Paper. London: DFID.

http://www.dfid.gov.uk/R4D/pdf/publications/HTNCapacityBuildingFinal210610.pdf

A practical guide on how to approach capacity building in research. It differentiates between capacity building at the individual, organizational and system levels.

Annor-Frempong, I, J. Roseboom and N.K.O. Ojijo. 2012. *A Pilot Study on Institutional and Organisational Changes in Selected National Agricultural Research and Education Institutes in Sub-Saharan Africa*. Accra, Ghana: FARA.

http://www.fara-africa.org/publications/

"This report summarises the results of a pilot study commissioned by the Forum for Agricultural Research in Africa (FARA) to test a methodology for monitoring institutional and organisational change in selected agricultural research and education institutes across sub-Saharan Africa currently implementing the Strengthening Capacity for Agricultural Research and Development in Africa (SCARDA) programme. The methodology uses Strengths, Weaknesses, Opportunities and Threats (SWOT) tables (which summarise the principal positive and negative factors affecting the overall performance of an institute towards its objective) to monitor institutional and organisational change over time and across institutes.

The methodology has been tested in eight of the 12 Focal Institutes (FIs) that have participated in the SCARDA programme since 2008. Key outcomes of this pilot study are that:

1. Nearly half of the 282 SWOT factors identified by the eight FIs did not change between 2008 and 2011. Of those that changed, 82% were in a positive direction and 18% in a negative direction. This aggregate picture of positive change outweighing negative change holds for seven of the eight FIs. Only in one instance, the negative and positive changes in SWOT factors were more-or-less in balance; and
2. Changes attributable to SCARDA intervention were recorded for 76 out of the 282 SWOT factors. Of these 76 changes, 79% were classified by the FIs as "moderate contribution" and 21% as "substantial contribution" by SCARDA. Moreover, 26% of the SCARDA interventions did not lead to an improvement in the SWOT factor, 59% to a moderate change in the SWOT factor, and only 15% to a substantial change in the SWOT factor.

The overall conclusion that one can distil from the eight case studies is that it is still too early to assess SCARDA's full impact in terms of institutional and organisational change. Only a few SCARDA interventions can be linked to a substantial improvement of the targeted SWOT factor. The large majority of SCARDA's interventions are still rather fragile and will require continued attention and consolidation in order to reap the benefits in terms of better performing organisations.

Important lessons learned from developing and testing the methodology are:

1. The usefulness of the methodology depends strongly on the quality of the effort that is being put into it.
2. The comparability of the SWOT tables can be improved significantly by introducing a standard toolkit and protocol for the institutional analysis (including a SWOT analysis) that can be used by both consultants and local counterparts.
3. A stricter adherence to the SWOT methodology is required. Most institutional analyses, conducted at the onset of SCARDA, only made an inventory of the SWOT factors, but did not systematically formulate strategies of how to *use* strengths, *stop* weaknesses, *exploit* opportunities and *defend* against threats.
4. In the case that such strategies are developed for each SWOT factor, one could refine the institutional change methodology considerably to help interrogate how the FIs successfully implemented the proposed strategies. This will give a more detailed insight into the institutional change process of an FI.
5. The change captured by the survey instrument for the different SWOT factors requires careful interpretation. It is less straightforward than may be originally perceived.
6. Standardisation of the labels used to identify SWOT factors is needed in order to facilitate comparisons across institutes and over time.
7. Some form of scoring or weighting of the SWOT factors would substantially improve the information that can be extracted from the cross-sectional and temporal comparison. However, it requires the discipline to do so at the time of the SWOT analysis.
8. The scale used – by the questionnaire – to record change requires some more explanation in order to make sure that the scores are comparable across institutes. It looks as if some evaluations have been stricter than others when scoring change.

In conclusion, the methodology to monitor institutional change based on SWOT tables is attractive because of its simplicity and flexibility – it can be used by any organisation. However, like any M&E tool, it requires the discipline of collecting information upfront as a baseline against which change can be measured. If implemented correctly, the methodology can help institutes to stay committed to improvement of their performance. Moreover, it offers donors a framework within which they can invest in improving organisations. Lastly, widespread adoption of the tool would create a permanent pool of information that can be used for meta-analysis."

Mbabu, A.N. and A. Hall (Eds.). 2012. *Capacity Building for Agricultural Research for Development: Lessons from Practice in Papua New Guinea.* Maastricht, The Netherlands: United Nations University-Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT).

http://www.merit.unu.edu/archive/docs/hl/201302_Capacity%20Building%20for%20Agricultural%20Research%20Development_Final.pdf

This book provides an overview of a concerted attempt (financed by AUSAID) to build agricultural research for development (AR4D) capacity in Papua New Guinea. AR4D, a term widely used in Africa, is part of a long history of approaches, concepts, and capacity building frameworks aimed at improving the

performance and impact of agricultural research. “There is, however, a considerable degree of ambiguity concerning what AR4D actually is. On the one hand there are those that see this as a partnership or multi-stakeholder-based protocol for conducting research. Others see this as a farmer-centric, farming systems-type of approach similar to participatory research. And there are others, including ourselves, who see this as a fundamental shift towards a systems-oriented approach to learning, innovation and capacity development.” The authors argue that the explicit [agricultural innovation] systems orientation of AR4D demands a different approach to capacity building. They cite Horton (2012): “For agricultural research organizations to shift their focus from doing research to using research to foster innovation, they are likely to need changes in the following areas: strategy formulation; accountability to end-users and beneficiaries; partnership policies; planning and evaluation systems; incentives; administration and finance; and organizational arrangements.” In other words, AR4D is not a quick fix, but requires profound changes throughout the whole agricultural innovation system in order to succeed.

The authors argue that “the state-of-the-art on AR4D and organizational development approaches for agricultural research has provided a strong set of principles for a new direction in capacity building: It needs to be learning-based and participatory; it needs to be results-driven and explicitly link research to development; it needs to take a systems view, whereby research is planned and executed as part of wider development agenda and involves partnerships with policy and practice stakeholders; and it needs to be a conscientious process whereby capacity building responds to the evolving context of the agricultural sector.”

After an excellent introduction on AR4D concepts and what they mean for capacity development, the authors describe the PNG experience in detail and derive lessons from that experience for wider use. They reckon that more solid evidence is needed that AR4D is actually delivering the promised impact.