

Designing Agricultural Research Linkages within an AIS Framework

David J. Spielman, International Food Policy Research Institute (IFPRI)

Catherine Ragasa, International Food Policy Research Institute (IFPRI)

Riikka Rajalahti, World Bank

SYNOPSIS

Consensus is growing that new ways of conducting agricultural research are needed. To date, the operational implications of these changes and strategies for making them efficient, effective, and sustainable have been discussed very little. Lessons on strengthening the connectivity between agricultural research and other innovation system actors are viewed through the lens of three types of economies—agriculture-based, transforming, and urbanized—and two strategies: (1) investing in “demand articulation” mechanisms to better identify the needs of different user groups and (2) designing “organizational interfaces” that help transform research into real goods and services. There is a case for both market and nonmarket approaches to improving demand articulation and organizational interfaces. They include investment in formal mechanisms that provide stakeholder input to research organizations, more participatory mechanisms that bring researchers and farmers together to solve problems, innovation platforms that address larger, more complex challenges with diverse actors, commercialization programs that move research into the marketplace, and financing mechanisms that encourage collaborative research. Careful adaptation to the specific innovation contexts, strategies, and mechanisms is prerequisite for success.

BACKGROUND AND CONTEXT

Agricultural research needs to be examined within the broader analytical framework of an innovation system, which means recognizing that innovation in agricultural development may occur in collaboration with, separately from, or even in spite of agricultural research organizations. The challenge is to make public research organizations more responsive, dynamic, and competitive within

this new landscape in agricultural development. To reach this goal, public research organizations will have to increase their relevance, their capacity to respond to a changing landscape, and their ability to produce goods and services that can be put to use in a socially or economically productive manner.

These statements are not a call for paying less attention to the quality of scientific inquiry and expertise in disciplinary fields. They are rather a call for greater interaction between researchers and other knowledge producers and users to maximize the quality of science and its impacts on society and the economy. Increased interaction means that public research organizations will continue to play a role in developing country agriculture but that their role must change. The key to this change will be flexible institutional arrangements that encourage dynamic, rapid responses to changing circumstances from public research organizations.

This TN examines specific investments in key design elements and approaches in three innovation contexts (box 4.5) similar to those discussed in the module overview. It focuses on key investments in articulating demand (identifying the needs of different user groups for the knowledge and information produced by research organizations) and designing organizational interfaces (modalities that help transform this knowledge and information into socially and economically relevant goods and services).

Research systems have undergone any number of reforms, ranging from rebuilding after a crisis to redesigning more complex and advanced systems. Little evidence points to which reforms actually work well in different types of research organizations and how these reforms might ultimately affect agricultural productivity and poverty. Without sufficient evidence, it is often difficult to provide conclusive insights into the returns on investing in large-scale reforms of research systems. The next best option is to examine

- (1) **Agriculture-based countries.** In these countries, farmers have limited access to agricultural markets, which in many cases do not function well. Most countries in sub-Saharan Africa are in this category. In agriculture-based countries, **research organizations** must develop an interface with their clients—primarily small-scale farmers, extension systems, and government decision makers—and with the rest of the national, regional, and global research system. The private sector engages mostly in licensing technologies to public breeding programs, multiplying improved seed developed by public breeding programs, distributing inputs such as chemical fertilizer, or providing other small-scale and localized agricultural products and services.
- (2) **Transforming countries.** Transforming countries host innovation systems in which agricultural markets are expanding and developing. A subset of farmers gain from good connections to markets. Transforming countries can be characterized by an increased reliance on market-based approaches to guide the contribution of agricultural research to the wider innovation system. *Many developing countries in South Asia, East Asia and the Pacific, the Middle East, and North Africa are in this category.*
- (3) **Mature innovation countries.** These countries have innovation systems in which agricultural markets function relatively efficiently and farmers are effective market players. *Most countries in Latin America and the Caribbean and many in Europe and Central Asia are in this category.* In transforming and mature countries, **research organizations** should take greater notice of market demand and rely on market-based approaches to guide their contribution to the wider innovation system. Research organizations are required to interface with a wider set of clients—smallholders and commercial producers, diverse private sector actors (input suppliers, processors, wholesalers, retailers, industry associations, exporters), other service providers, and consumers—to create venues for them to express their needs and align national priorities to research agendas.

Source: Authors, based on World Bank (2007).

different reform processes to understand the impact pathways through which they are expected to work.

INVESTMENT NEEDED

This note describes *nonmarket* and *market-based approaches* to investment, starting with approaches that fit particularly well with agriculture-based contexts and moving to more commercial, market-oriented approaches. The note does not provide an exhaustive list of investment mechanisms but features the mechanisms that are most relevant for developing countries:

1. Strengthening information sharing and demand articulation in research systems through formal coordination organizations, enhanced communication, and ICTs.
2. Promoting greater participation of farmers and other clients in technology development processes.
3. Technology transfer and commercialization approaches.
4. Financing mechanisms for multistakeholder approaches.

Table 4.2 summarizes the approaches, their purposes, and the key knowledge assets used and exchanged as part of each approach. The approaches or mechanisms can be selected and combined to fit the particular need for innovation in a given context.

Strengthening information sharing and demand articulation in research systems through formal coordination organizations, enhanced communication, and ICTs

In many countries, formal organizations facilitate regular exchanges of information and identify research priorities. These organizations include committees, agencies, and other formal bodies that obtain farmers' input on research results (for example, their opinions of the performance of new cultivars), on longer-term priorities for research and/or competitive research funds, and on the wider policy issues associated with agricultural production and markets.

The public sector often leads and manages the process of setting up these formal organizations. Often they include representatives of farmers, extension services, the research system, and ideally other actors in the public sector, private sector, and civil society. Both centralized and decentralized approaches are applied. Organizations at the provincial/zonal level, such as the Research Extension–Farmer–Input–Linkage System in Nigeria or the Research and Extension Linkage Committees in Ghana (box 4.6),

particularly fit agriculture-based contexts and tend to focus on consultation and receiving farmers’ input on research results.

Organizations that operate at the national level use a more sophisticated set of tools for priority setting aside from stakeholder consultations, including tools for scenario and technology foresight, information databases, and M&E of research programs. Examples include the Senegal Agricultural Services and Producer Organizations Project

Table 4.2 Approaches to Strengthening the Articulation of Demand and Interfaces with the Agricultural Research System in Agriculture-Based, Transforming, and Mature Innovation Contexts

Approach	Purpose	Key assets	Examples (sources)
Formal coordination organizations	Information exchange, priority setting, coordination, fund allocation	Scientific information; extension and advisory services	<i>Agriculture-based:</i> Research Extension–Farmer–Input–Linkage System (REFILS) in Nigeria (Koyenikan 2008); Research and Extension Linkage Committees (REALCs) in Ghana (World Bank and IFPRI 2010); Senegal Agricultural Services and Producer Organizations Project <i>Transforming and urban:</i> Fund governance and national research/innovation councils or forums
Communication and ICT	Share information; demand articulation		See <i>Information and Communication Technologies for Agriculture Sourcebook</i> (World Bank 2011, forthcoming).
Participatory research	Engage farmers in research priority setting, selection, testing, and experimentation	Scientific information; extension services; capacity/methodology in participatory approach	Participatory plant breeding (Sperling et al. 2001; Morris and Bellon 2004) Central America Learning Alliance (Faminow, Carter, and Lundy 2009); CIALs in Colombia, Honduras, Ecuador, Bolivia, and Nicaragua (CIAT 2006; Quiros et al. 2004)
Codesign approaches	Engage diverse stakeholders in the entire R&D cycle	Scientific and local information; capacity in codesign approach	Liu (1997); Almekinders, Beukema, and Tromp (2009); Hocdé et al. (2009); Bernet et al. (2006, 2008)
Innovation platforms	Promote co-innovation; exchange information; identify opportunities and set priorities; promote policy change	Public and private technologies; capacity to reach commercial and underserved markets; private financing; farmer-private sector-policy maker linkages	<i>Agriculture:</i> Civil society partnerships: Papa Andina (Thiele et al. forthcoming; Devaux et al. 2009, 2010; Horton et al. 2010; Smith and Chataway 2007) <i>Transforming:</i> Agricultural innovation networks in Argentina (Ekboir and Parellada 2002; Trigo et al. 2009), Bolivia (Monge et al. 2008), Mexico (Ekboir et al. 2009), Andean South America (Devaux et al. 2009, 2010; Horton et al. 2010), and the Netherlands (Klerkx, Aarts, and Leeuwis 2010); Research consortiums: CLAYUCA on cassava (Patiño and Best 2002; see IAP 5 in module 1) <i>Urban:</i> Netherlands (Janssen and Braunschweig 2003; Klerkx and Leeuwis 2009a) <i>International and regional research networks:</i> CGIAR, FARA, ASARECA, APAARI
Consortiums			Australia; NAIP India (IAP 2)
Technology transfer	Acquire technology	Scientific information and tools; capacity for dealing with international agreements	<i>Agriculture:</i> Material transfer agreements between international and national research centers for wheat improvement (Dubin and Brennan 2010; Louwaars et al. 2005) and biotechnology (Byerlee and Fischer 2002) <i>Urban:</i> Agricultural biotechnology (Byerlee and Fischer 2002); drought-tolerant maize research (AATF 2011)

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Table 4.2 Approaches to Strengthening the Articulation of Demand and Interfaces with the Agricultural Research System in Agriculture-Based, Transforming, and Mature Innovation Contexts (continued)

Approach	Purpose	Key assets	Examples (sources)
Commercialization programs	Commercialize public research	Public technologies; capacity to commercialize new products	<i>Transforming:</i> ICSRISAT Hybrid Parents Research Consortia for sorghum and pearl millet (Gowda et al. 2004; Pray and Nagarajan 2009); Sustainable Commercialization of Seeds in Africa (SCOSA) (Jones 2006) <i>Urban:</i> Cooperative R&D agreements (Day-Rubenstein and Fuglie 2000); Plant genetic IP management (Louwaars et al. 2005)
Public-private research partnerships	Develop new products	Scientific information, tools, and materials; managerial capacity	East Coast fever vaccine development (Smith 2005; Spielman 2009); agricultural research (Spielman, Hartwich, and von Grebmer 2010); see also IAP 2 in module 6
Science parks and business incubators	Develop new products	Scientific information and tools; managerial capacity; private and public capital	CIAT and ICRISAT (Spielman, Hartwich, and von Grebmer 2010); see also TN 3 and IAP 1 in module 5
University-industry research collaborations	Promote co-innovation; commercialize public research	Public technologies; capacity to commercialize new products	Agricultural biotechnology (Ervin et al. 2003)
Alternative funding mechanisms	Farmer-funded research; finance research	Financing from financial markets and donors; specialized scientific services	Competitive grants and innovation funds (World Bank 2006, 2010; Gill and Carney 1999); Research prize schemes (Masters 2003); farmer levies (Klerkx and Leeuwis 2009b); market segmentation schemes (Kolady and Lesser 2008; Lybbert 2002)

Source: Authors.

Note: APAARI = Asia Pacific Association of Agricultural Research Institutions; ASARECA = Association for Strengthening Agricultural Research in Eastern and Central Africa; CIALS = Local agricultural research committees; CGIAR = Consultative Group on International Agricultural Research; CLAYUCA = Latin American and Caribbean Consortium to Support Cassava Research and Development; FARA = Forum for Agricultural Research in Africa.

Box 4.6 Research-Extension-Linkage Committees in Ghana: Experience and Lessons

In Ghana, Research-Extension-Linkage Committees (RELCs) include producers, researchers, and extension agents from the Ministry of Food and Agriculture (MoFA). The committees facilitate dialogue and elicit better guidance from producers about local research and extension efforts. Five RELCs were piloted, one in each of the country's major agroecological zones, under the World Bank-funded Agricultural Services Project. Eventually the committees were expanded to cover each of Ghana's 10 regions. Each regional RELC has 15 members, including two representatives of farmer organizations, one representative from a non-governmental organization, one representative of agribusiness, and representatives from research and extension.^a Under the Agricultural Services Project, the second call for proposals from the competitive

research grant scheme was based on the RELCs' identification of farmers' problems. Thirteen research projects from seven regions were approved for funding.

Despite this effort at planning from the farm level up, the RELCs proved ineffective in strengthening links between research and others in the AIS. Funding for implementing RELC initiatives has been limited, partly because responsibility for allocating operating funds is divided between the national research institute (the Council for Scientific and Industrial Research) and MoFA. Perhaps owing to these financial constraints, the RELCs have not engaged greater numbers of farmers and end users and have had little influence on the research agenda. Sustainable financing for farmers' and end users' participation in the RELCs is likely to have made them more effective.

Source: World Bank 2007; Riikka Rajalahti, personal communication.

a. According to the project's 2002 procedure manual.

(box 4.7), research councils (module 1, TN 1), and competitive funds (module 5, TN 2).

Improved awareness of research programs, results, and applications—among research partners (national, international) and other stakeholders, including clients—are important for articulating demand in increasingly decentralized AISs and developing a platform for information sharing and collaboration. The key investment elements include development of a communications strategy and program; capacity building for staff on communications and ICTs; hardware and software for collecting and storing data, and a telecommunications and Internet platform. For details and examples, see World Bank (2011).

Promoting participation of farmers and other actors in technology development

Participatory research approaches, codesign, and innovation platforms offer pathways for farmers and other clients to develop agricultural technology with researchers. The next sections discuss these approaches and specific corresponding investments. The concluding discussion focuses on the potential for research consortiums to strengthen links between research and other actors in the AIS.

PARTICIPATORY RESEARCH APPROACHES. Participatory approaches identify farmers' demands and bring farmers' knowledge as well as researchers' knowledge to bear on

Box 4.7 Lessons from Senegal's Agricultural Services and Producer Organizations Project

The Agricultural Services and Producer Organizations Project (PASAOP) strengthens end-users' demand for services and public research institutions' ability to meet their demands. In its first phase (1999–2006), PASAOP established a network of producer organizations in 142 of 320 rural council areas, along with decentralized, demand-driven agricultural services. In its second phase (2006–11), the project further strengthens the institutional framework, extends the coverage of agricultural advisory services nationwide, supports the emergence of private service providers, strengthens research capacity and focus, and further empowers producer organizations, while increasing their social accountability and representation. Both project phases have built on the following approaches:

- **Restore the focus of ministries** active in agriculture on their core public functions: policy formulation, monitoring, and evaluation. Create specific directorates for policy analysis, forecasts, and statistics. Decentralize services with the creation of regional directorates.
- **Replace the traditional technology transfer model** with demand-driven support. Decentralized advisory services are managed jointly (including planning and evaluation) by a semipublic National Agency for Agricultural and Rural Advisory Services (ANCAR), producer organizations, and private agribusiness.
- **Establish transparent, competitive financing** for research on agriculture and agroprocessing through

the National Fund for Agricultural Research (FNRAA).

- **Engage producer organizations** in decision making as genuine advocates of proposals. Producers also chair the management committee of FNRAA to ensure that research programs are relevant to their needs.
- **Link producers** through a network of rural consultative forums (CLCOPs) in 152 rural council areas so producers contribute fully to defining, implementing, and evaluating research and extension programs. Producer organizations have also established and manage their own Demand Driven Rural Services Fund, which allocates resources to micro-projects prepared by producer organizations.

Benefits

To date, PASAOP has helped improve the quality and selling price of groundnuts, level and quality of community seed stocks, beneficiaries' incomes (12 percent higher), and nonfarm household income. Producer satisfaction with services is 80 percent against a target of 100 percent. Food security increased among 62 percent of producers against a target of 60 percent. In producer organizations, 45 percent of members adopted at least one technology in their production systems against a target of 50 percent. The agricultural research system generated 22 technologies. Cofinancing of FNRAA by other

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Box 4.7 Lessons from Senegal's Agricultural Services and Producer Organizations Project (continued)

stakeholders (government, other donors, commodity organizations, and the private sector) is expected to reach 30 percent.

Lessons

- **Invest in producer organizations.** Local institutions can responsibly and efficiently implement their activities and limit the need for a project to establish an implementation unit. Producer federations with adequate project support improved their efficiency and internal governance (quality of records, meetings, actions taken, satisfaction of members). Demand-driven funds that supported physical investments and equipment were more effective than those focused only on soft investments.

- **Two channels for research proposals (from researchers and from users) provided flexibility.** They made it possible to respond to producers' immediate concerns as well as opportunities identified by scientists.
- **Complement core funding with competitive funding.** Together, these two mechanisms guarantee that institutional development continues. Funding for operating costs goes directly to research teams working on projects relevant to users, to whom they are accountable. Core funding for developing human resources is essential to elicit relevant proposals of good quality.
- **Specific pro-poor strategies must be designed into the project.** The project's second phase seems to have had a greater impact in richer households than poorer households.

Sources: Diaw, Samba, and Arcand 2009 on impact assessment of Phase 2 of PASAOP; World Bank Project Appraisal Documents for Phases 1 and 2 of PSAOP; World Bank Implementation and Completion Report for PSAOP.

Note: PSAOP = Programme d'Appui aux Services Agricoles et aux Organisations Paysannes; ANCAR = Agence Nationale de Conseil Agricole et Rural; FNRAA = Fonds National pour la Recherche Agricole et Agro-Alimentaire; CLCOP = Cadre Local de Consultation des Organisations de Producteurs.

agricultural problems. Farmers (and others) participate in monitoring and evaluating the results. Some participatory research is done in farmers' fields. This approach is particularly suited to *agriculture-based countries* in which resources are at a premium and farmers are often isolated from others in the AIS. The approach allows research organizations to complement their programs in cultivar improvement and crop management with work on more integrated and natural resource management issues, such as common resource management of pastures, shared water resources, fisheries, and communal forests, and incorporate gender and community-based development perspectives through farmer organizations, forest user groups, and local savings and credit associations.

CODESIGN APPROACHES. Codesign approaches (discussed in detail in TN 4) seek better articulation between the supply of research (from researchers) and demand for research (from users). Researchers engage systematically with a heterogeneous set of actors, which may include farmers, input suppliers, traders, processors, researchers, NGOs, and

government officials in the iterative, adaptive, and flexible process of developing innovations. The core principles of codesign include joint planning, implementation, and decision making related to all activities that foster innovation; close coordination among stakeholders at all strategic and operational levels; and combining scientific, other technical, and local knowledge and other resources.

Codesign is often used *when problems are complex and/or the scale involved is challenging*. Examples include the shared management of a dwindling natural resource held in common (a forest or water source, for example); the period of adjustment to new policies or market operations; the development of shared understanding of problems and their solutions, when there is potential to do so; and problems for which previously designed solutions or scientific and technical knowledge are not available. Given the issues of scale involved in such a large group of actors and their numerous concerns, codesign relies on at least some of the concerned stakeholders to have the experience and skills to facilitate, coordinate, and negotiate multistakeholder efforts (module 1). The Papa Andina program

implemented in Bolivia, Ecuador, and Peru successfully combined and applied codesign and innovation platform approaches (TN 4, box 4).

INNOVATION PLATFORMS. Innovation platforms (or networks and forums) assemble stakeholders to share information, identify opportunities, discuss problems, and agree on joint activities related to a shared interest, often with a specific commodity/cluster focus. They usually provide a means for many participants to exchange opinions but tend to imply less commitment to addressing the needs identified, compared to codesign approaches, consortiums, or competitive grant schemes. Innovation platforms focus on all kinds of innovation, not necessarily research alone, and they may be led by actors other than researchers. Even so, they present an important venue and opportunity for many research organizations to engage with other AIS actors, improve their understanding of how they can best fit into the AIS, and develop partnerships. In *transforming countries*, innovation platforms are likely to be more mature than in *agriculture-based countries*, where public support and funding are prerequisites for success. The key assets or contributions by each actor in the interface may be explicit (for example, they may consist of scientific or market information, tools, and materials, both proprietary and nonproprietary) or more implicit (such as the capacity to manage complex projects, move technologies through regulatory processes, or market and distribute new products).

Examples of innovation platforms include the Central America Learning Alliance, a multistakeholder network that promotes rural enterprise development (IAP 4), and the innovation network that promoted zero-tillage cultivation practices in Argentina (module 1, IAP 1). Papa Andina (TN 4) and the client-oriented research management approach (box 4.22 in TN 5) apply both nonmarket and market-based strategies.

INVESTMENT NEEDS IN PARTICIPATORY AND CODESIGN APPROACHES AND INNOVATION PLATFORMS. Specific investments improve the likelihood that these approaches and platforms will function more successfully.

- **Invest in researchers' capacity to work in innovation systems.** Researchers must have the capacity to diagnose innovation systems and the ability to participate in and sometimes facilitate group processes involving people with diverse stakes in a commodity or value chain. Aside from their technical and scientific expertise, they will

need the skills involved for organizing actors, coordinating activities, and consulting, negotiating, monitoring, and evaluating.

- **Invest in other partners' skills.** Farmers, universities, NGOs, the private sector, and others will need skills in designing partnerships, building trust, and effective communication. Farmer organizations often need help in learning how to articulate their demands, establish links to local government, and engage in social learning and experimentation to innovate rather than simply demonstrate or accept technological "fixes."
- **Invest in bringing people together.** Operational funds are needed to run committees and cover the costs of face-to-face, facilitated group meetings (coordination, facilitation) and the collective action that are inherent to collaboration at all stages of the codesign process.
- **Invest in innovation brokers.** A good facilitator or a project team is required to take an initiative forward. Innovation brokers can limit the failures that occur when different interests and conflicting agendas frustrate initiatives designed to foster partnership. They can also reduce competition between the public and private sectors, creating a more coordinated approach to problem solving. Innovation brokers do not often emerge of their own accord. Their facilitation role needs to be funded, supported, and linked to activities in research, extension, and the broader innovation system.
- **Invest in incentives for participation.** These incentives often take the form of funding that makes partnerships work: operational costs and costs of joint R&D.
- **Invest in value chain analysis and development.** Investments in value chain development are a key entry point for research organizations in *transforming countries* to contribute solutions that enhance the benefits (and lower the costs) to actors along the value chain. Tools such as value chain analyses—including participatory approaches to such analyses—can identify constraints and market opportunities at different stages of the value chain as well as entry points for support.

RESEARCH AND INNOVATION CONSORTIUMS. Consortiums are more formal mechanisms than networks or innovation platforms. They bring together diverse partners around a specific and common problem requiring research investment, jointly define R&D strategies, and finance and implement the subsequent research-innovation project. They often—but do not necessarily—focus on applied R&D. Consortiums often require multidisciplinary teams

consisting of private, public, civil society, and producer actors. Most consortiums have a lead organization, and each partner has a specific role and commits resources. Contributions from a range of actors, including private enterprises, cover various aspects of R&D (demand identification, R&D investment, technology transfer and adoption). Consortiums are often funded through competitive grants (which match funds to resources mobilized by partners) for a limited period.

Australia (box 4.8) and the Netherlands (box 1.14 in module 1, TN 1) are examples of *mature urban innovation* contexts where a consortium approach helped R&D meet specific challenges. Consortium approaches have shown promise in *transforming countries*; see the discussions of approaches in India (IAP 2) and Chile (IAP 3).

Technology transfer and commercialization approaches to integrating private actors

Technology transfer is the foundation of many research programs in *agriculture-based* countries and prevalent in *transforming* and *urbanized* countries. Transforming and more mature innovation contexts increasingly rely on formal transfers of technology from public research organizations, universities, and the private sector. Such technology may require IP protection and/or other legal agreements that transfer property rights to commercial or international partners. Many of the technology transfer and commercialization approaches in these countries build on approaches introduced earlier, but they require a higher level of capacity with respect to advanced science and technology, complex regulatory systems, IP protection, sophisticated

Box 4.8 Design of the Australian National Agricultural Innovation System

Australia's AIS is one of the most dynamic and successful in the world. Direct engagement of producers through their financing and oversight of commodity-focused (mainly applied) research was the primary mechanism for gaining insight into the needs and demands of key user-groups. Sharpened priority setting, increasingly involving *ex ante* economic analysis of competing proposals along with *ex post* impact assessments, has been the hallmark of the approach. Agricultural research intensity has been maintained at nearly 0.04 of agricultural GDP, among the highest levels in the world, and total factor productivity for agriculture has been close to 2 percent per year since the major reforms in the agricultural research system began in the mid-1980s.

A key feature of the reforms is the creation of Cooperative Research Centres (CRCs), which are joint agreements between research providers to undertake R&D in particular areas. CRCs must comprise at least one Australian end-user (either from the private, public, or community sector) and one Australian institution of higher education (or research institute affiliated with a university). These institutions work for a limited period (generally seven years) to resolve technological problems in a multidisciplinary fashion. The involvement of universities and their disciplinary expertise is especially important for linking industry

Source: Jock Anderson, personal communication.

demand to academic centers of excellence in joint problem-solving.

Traditionally Australia has invested relatively heavily in agricultural research through a blend of public and private (producer levy) funds, which were largely used by federal and state government agencies with some producer oversight through farmer membership on various advisory committees and an institutional watchdog (the Productivity Commission for institutional learning and ensuring accountability). Producer funding was matched equally by federal government support of up to 1 percent of respective commodity GDP.

A *key lesson* is that a charismatic change leader with a relevant vision is critical. In this case, it was a minister of primary industries, who was insightful and effective (originally a farmer, then a research agricultural economist and a politician). The strong (albeit less than perfect) accountability mechanisms built into the new processes, such as the CRCs, surely helped greatly. A major lesson for other countries is that, given the inherent complexity of the AIS, it is critical for public policy analysts to keep pursuing their understanding of the realities and opportunities in agricultural research as it evolves and to keep a sharp eye on the effectiveness of institutional arrangements.

markets and market infrastructure, and international trade considerations.

The capacity to manage formal technology transfer mechanisms is critical to engage effectively in public-private partnerships and, increasingly, to transfer technologies that can be disseminated through market channels. *Technology transfer offices* are special units affiliated with a research organization or university with a mandate to identify and protect as well as facilitate the use and commercialization of research results. These offices can expand the recognition of the research organization's work (thereby strengthening public perceptions of its value), move technologies to end-users (seed companies, farmers) on an exclusive or nonexclusive basis, and generate revenues to fund continuous research.

Technology transfer offices can provide special expertise on IP protection and/or legal agreements and contribute to formal transfers of technology from public organizations or universities or from the private sector to commercial or international partners (see box 6.20 in TN 3 of module 6 and TN 5 in module 5). Several examples of this interface have been used successfully to disseminate hybrid parent lines of pearl millet and sorghum in India, with substantial improvement in the availability of improved seed and yields for small-scale farmers in semiarid and arid tropics (Gowda et al. 2004; Pray and Nagarajan 2009). Aside from

technology transfer offices, other pathways to technology transfer may be applied (summarized in box 4.9).

Some technology transfer offices also host *incubators* to help technology-oriented firms (often established by researchers) commercialize new technology. Incubators provide hands-on management assistance, access to financing, business and technical support services, shared office space, and access to equipment. For details, see module 5, TN 3.

SCIENCE PARK APPROACHES. Science parks (also called technology or research parks) are a mechanism for fostering public-private partnerships in *more mature innovation contexts*.¹ Science parks are organizations managed by specialized professionals, whose main aim is to increase local wealth by promoting a culture of innovation and improving the competitiveness of local businesses and knowledge-based institutions. A science park stimulates and manages the flow of knowledge and technology among universities, R&D institutions, companies, and markets; facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high-quality space and facilities.

Science parks function best where there is investment capital from the private sector, industrial engineering expertise, and a sufficient knowledge and technology base.

Box 4.9 Technology Transfer Pathways

Technology transfer agreements. The classic example of technology transfer agreements is the formal exchange of breeding materials for crop improvement, typically from international research centers or universities in industrialized countries to national research organizations in developing countries. Scientists and research managers in developing countries require additional skills to understand the increasingly complex material transfer and intellectual property agreements that govern technology transfer; they must also expand their linkages to international and regional science networks. Great success has been achieved with technology transfer programs (for example, for wheat and rice improvement in Asia, NERICA rice in Africa, and orange-fleshed sweet potato in several postconflict countries in Africa).

Source: Authors.

Commercialization programs. These programs create windows for private companies or entrepreneurs to access public research outputs and move them into commercial use. Often this approach is used to move improved breeding material from public research organizations to private seed companies. For example, the Hybrid Parents Research Consortia of the International Crops Research Institute for the Semi-Arid Tropics have provided more than 35 Indian companies with improved sorghum, pearl millet, and pigeonpea lines for commercial use. The program for Sustainable Commercialization of Seeds in Africa, the Eastern and Southern Africa Seed Alliance, and the West Africa Seed Alliance are also designed to improve the private sector's access to breeding materials and strengthen its seed marketing capacity.

As discussed in the module overview, they are a useful nexus between the private sector and research institutes (particularly universities), taking promising research products to market and providing backstopping for product modification. Their diverse services include facilitating the creation of public-private partnerships for research, providing infrastructure, and providing other services, including business development. The scope of this note does not allow the numerous science parks to be discussed in detail (including China's agricultural demonstration and technology parks; CIAT's Agronatura, and France's Agropolis); see module 5, IAP 1 on the incubator affiliated with the Agri-Science Park of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

Financing mechanisms for multistakeholder approaches

Transforming and mature countries often demonstrate a higher level of complexity and capacity when it comes to funding research organizations and activities, especially where functioning markets exist alongside an organized agricultural sector. Aside from public core funding for research, a great number of funding mechanisms or other arrangements (such as levies on sales, public-private partnerships, cofinancing with farmer organizations and trade associations,² R&D tax deductions, joint ventures, or research partnerships, see IAP 3 on Chile) incentivize and reduce the transaction and risk management costs associated with collaborative research (for a summary on financing agricultural innovation, see module 5, TN 6). This TN briefly describes the two main mechanisms—competitive research grants and matching grants—which are described in detail in module 5, TN 2.

Competitive research grants are a common mechanism for funding basic, strategic, and applied research through competition based on scientific peer review. The aim is to focus scientists' efforts on high-priority research or new fields of expertise, improve the relevance and quality of agricultural research, promote research partnerships, and leverage research resources (from the public or private sector). See IAP 2 for an example of a competitive research grant scheme to promoting multistakeholder consortiums in India (World Bank 2010). Funds for competitive grant schemes usually come from the public sector and are managed by a public or semiautonomous organization. Competitive grants have been used to fund consortiums working on specific research themes.

Matching grants are used for financing near-market technology generation, technology transfer and adoption, or business-related innovation, often by including multiple

stakeholders (see module 6, IAP 1 for a matching grant scheme to develop agribusiness in Zambia). Matching grants require a financial commitment from the beneficiaries (farmers, entrepreneurs) and therefore may be more effective than competitive research grants at enhancing the dissemination and use of knowledge and technology. They are also better suited for funding overall innovation and activities requiring private sector engagement.

Both competitive research grants and matching grants involve short- to medium-term funding arrangements. They should complement, never substitute for, stable funding for long-term research, private sector development, human resource development, and infrastructure maintenance and development.

POTENTIAL BENEFITS

The immediate benefits of these investments are straightforward. Research organizations gain greater relevance and responsiveness, ultimately leading to greater impact on agricultural development, food security, and poverty reduction. In many agriculture-based countries, these impacts are measured in terms of increased yields (output per unit of land) and production (total output).

Where markets operate with some degree of efficiency, potential benefits may include higher returns to crop cultivation (Kaaria et al. 2009; Thiele et al. forthcoming; Devaux et al. 2009, 2010; Cavatassi et al. 2009). Potential benefits also extend to improvements in gender aspects of agricultural development, such as changes in the household assets owned by men and women.

Beyond the immediate benefits to productivity, output, and welfare, these approaches carve out a niche for research organizations within a rapidly changing agricultural landscape. They provide research organizations with new clients and markets as well as access to new resources and assets. In urbanized systems particularly, an improved interface between research and other AIS actors may accelerate the rate of innovation by bringing the best science to bear on real problems and ensuring that sufficient resources are allocated to solving problems. The research system will become more responsive to the demands of society because users such as farmers and consumers have many different pathways to express their needs.

POLICY ISSUES

Most issues related to the policies and governance structures that enable research institutions to participate more

fully and successfully in the AIS are detailed in module 6. A few key issues should be mentioned here, however.

- **Sustainability requires managerial and structural reforms.** Research organizations often organize their personnel and assets by discipline, but this form of organization makes it costly to bring personnel and assets together to resolve problems in agricultural value chains. Management and structural reforms are vital to overcome this barrier; see the discussion in TN 5.
- **Institutional change and reform require stable, long-term support.** Efforts to encourage research organizations to interface with other user-groups and respond to their demands require considerable time, effort, and resources. Policy makers must commit the time, space, and funding to implement reforms and build the related capacity.
- **The participation of civil society, including women, may require specific policy initiatives.** Farmer associations and community-based organizations cannot operate in their members' interests in an environment hostile to grassroots and women's participation. Policies to foster equitable participation and social mobilization can (for example) provide operational funds to build marginalized groups' capacity to participate, cover the costs of their participation, and require that financing mechanisms have specific criteria to promote inclusiveness.
- **Are public funds used where they are most needed?** A value chain approach with a focus on multiple stakeholders can lead public research organizations to serve those who need their services least. Research organizations typically struggle with such trade-offs. For example, should they develop technologies for high-potential agricultural areas where the gains are likely to be high, or should they concentrate on technologies suited to both high- and low-potential areas? Decisions on how to address these tradeoffs require strong leadership from policy makers to ensure that public funds are used as intended.
- **Foster a conducive investment environment.** The key policy issue for a mature innovation system is to create a climate that supports private sector participation and development. Policies are needed for public research to contribute to private participation (through sound regulatory frameworks, for example) and also to ensure that women and the poor are included in the activities and benefits of innovation.

LESSONS LEARNED

The following lessons related to designing agricultural research linkages within an AIS are grouped into general lessons, lessons on the approaches that are best in particular innovation contexts (agriculture-based, transforming, and mature urban countries), and lessons related to particular mechanisms linking research to other AIS actors.

General lessons:

- **While large structural reforms are a good investment, smaller, more evolutionary, and incremental approaches to systemic change sometimes work best.** Invest in stepwise efforts to engage diverse user-groups, define problems collectively, build joint action plans, develop internal capacity, and learn through iterative processes. Such interventions sometimes involve only short-lived projects, marginalized administrative units, short-term bridge financing, or small team initiatives, but they foster responsiveness, dynamism, and competitiveness. Often they are more grounded in a specific innovation challenge.
- **Experiences from industrialized countries can prove instructive.** For example, Australia's approach to formalizing joint public and industry funding for its rural research program, and its regular and broadly consultative review of progress, could be effective in other contexts.
- **Invest in a mix of integrated approaches.** The appropriate mix depends on the specific circumstances of a country's agricultural research system, but it could involve a combination of formal research/innovation governance arrangements, participatory or codesign research approaches, and more commercially oriented approaches and financing mechanisms.
- **Approach capacity strengthening more comprehensively and iteratively than in the past.** Bench scientists require management training to interact effectively with other AIS stakeholders and ultimately improve the quality and impact of their research. Develop courses and learning materials based on experimentation and rigorous assessments of approaches that work or do not work in different contexts. To create a critical mass of researchers with skills suited to the AIS, integrate participatory processes and innovation network techniques into agricultural education systems.
- **Organizations also need new capacities and incentives to reform.** The ability of researchers and research organizations to leverage constructive interactions at some lower experimental level depends on the signals—authorization,

encouragement, or financing—from higher levels. In designing and implementing strategies to facilitate interactions and linkages, incentives and motivating factors among staff and leaders of research organizations (and other organizations with which they interact) must be assessed with care. Organizations need to enhance support for risk-taking managers and collaborative teams experimenting with learning approaches—but coupled with periodic external evaluations. Change of the kind described here requires strong, long-term leadership and political commitment in addition to incentives.

Lessons specific to particular innovation contexts:

- ***In agriculture-based countries, improve researchers' responsiveness to farmers' needs and increase access to global science and technology through a diversified, cross-cutting approach to participatory research and technology transfer.*** Strengthen individuals' capacity to use participatory approaches by building skills in facilitation, negotiation, conflict prevention and resolution, building relationships and trust, and developing the rules of the game. Broaden research organizations' access to technology by expanding their links to international science networks and their understanding of complex material transfer and IP agreements.
 - ***In transforming countries, use combined market/non-market approaches (making use of the skills just described) to engage the private sector more actively and encourage opportunity-driven entrepreneurship.*** Public sector orchestration and financing are key to addressing transaction costs (of collective action and negotiation, for example), reducing risk, and providing incentives. Innovation networks and platforms are vital tools to identify opportunities, set priorities, and influence the research agenda.
 - ***In urban countries, policy makers and practitioners can invest in sophisticated competitive funding mechanisms.*** The channels through which user groups articulate their needs should be advanced enough to ensure that science, technology, and innovation respond to market opportunities and that public research organizations work alongside the private sector and other stakeholders.
- Lessons related to specific mechanisms:
- ***Pay careful attention to the design of multistakeholder approaches and platforms, because they do not work in all contexts.*** These platforms need good facilitation to bring stakeholders (with their potentially divisive power relationships, capacity differences, and levels of interest) together. To sustain these programs, enhance negotiation and conflict management, improve the representation of poor and marginalized farmers, fully fund communication and knowledge management, and clearly define roles and functions of advisory committees, secretariats, and members. Engagement of high-level policy makers is often crucial.
 - ***It takes time to form and sustain networks or platforms.*** These interfaces require clear priorities, roles, and milestones. Substantive capacity strengthening of all partners in partnership design, trust-building, and effective communication is required for these approaches to work, along with incentives for participation.
 - ***Consortium approaches have the advantage of a problem-oriented focus.*** This focus permits the definition of partners' objectives, goals, and responsibilities, which in turn permits better management and evaluation of the collaborative effort. The disadvantage is that the reason for collaboration ends the moment that the problem ceases to need attention.
 - ***Innovation brokers play an important role in facilitating change in an innovation system.*** More formal approaches to innovation brokering include the use of research coordination councils, committees, and other bodies (see module 1, TN 2).
 - ***Analyze the pros and cons of new funding mechanisms carefully before introducing them.*** Matching grants may better suit innovation contexts where private sector engagement is crucial and where dissemination requires significant attention. Competitive research grants can develop high-quality research portfolios, but they tend to have high operational costs and have been ineffective in engaging the private sector and disseminating knowledge and technology. Small research systems may not allow sufficient scope for real competition.