



KNOWLEDGE AND INNOVATION FOR AGRICULTURAL DEVELOPMENT

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Every day, millions of rural people who depend on agriculture confront technical, economic, social, cultural, and traditional obstacles to improving their livelihoods. To cope with these obstacles, the rural poor draw on indigenous knowledge and innovate through local experimentation and adaptation. Indigenous knowledge alone, however, is not enough to deal with the complex problems facing the agricultural sector. Emerging issues such as high food prices, climate change, and demands for biofuels require complementary knowledge from formal agricultural research and development (R&D) and support from policies and other institutions. Formal and informal knowledge and innovation must therefore be linked to accelerate sustainable agricultural development.

Knowledge, defined as organized or processed information or data, is fundamental in the pursuit of innovation. For innovation to occur, knowledge must be created, accumulated, shared, and used. Innovations—new ideas, practices, or products that are successfully introduced into economic or social processes—can involve technologies, organizations, institutions, or policies. Innovation means putting ideas, knowledge, and technology to work in a manner that brings about a significant improvement in performance or product quality.

Advancing agricultural development requires knowledge and innovation in several key areas:

- **Technology.** While many good technologies are “on the shelf,” emerging issues such as climate change require new research to develop drought-resistant, flood-resistant, and short-duration crop varieties.
- **Institutions.** More socioeconomic research is needed to understand institutional constraints to innovating to improve livelihoods. Institutions are the system of rules that constitutes the environment within which innovations occur—laws, regulations, traditions, customs, beliefs, norms, and nuances of society.
- **Policies.** Appropriate, relevant, and timely public interventions are needed to promote and facilitate the creation, sharing, and use of knowledge for innovations.
- **Organizations.** Public and private groups and companies must innovate to become more effective and efficient in the services they provide.

To foster innovations in agriculture, policymakers must scale up investments in agricultural science and technology, research and extension, agricultural education and training, and farmer organizations and other local institutions—and do so in

ways that will spread advances in knowledge and innovation as widely as possible.

The Need for Agricultural Research and Development

Many past investments in agricultural research and development (R&D) have paid off handsomely. The *World Development Report 2008* provides evidence that investment in agricultural research resulted in an average rate of return of 43 percent in 700 development projects in developing countries. Other research has shown that for every 1 percent increase in agricultural growth, rural poverty falls by 1.83 percent, indicating an indirect link between agricultural R&D and poverty reduction. Using provincial-level data for China for 1970–97, researchers showed that the poverty reduction effect per unit of additional agricultural R&D investment ranked second only to investment in rural education. Studies by researchers from the Consultative Group on International Agricultural Research (CGIAR) show that the biggest payoffs for reducing rural poverty and increasing agricultural growth came from investments in agricultural R&D, education, and rural infrastructure, particularly roads. These investments must therefore be treated as a composite strategy for rural development.

In spite of high returns to investments in agricultural research, such investments are extremely low in the countries that have high rates of rural poverty. In low-income countries, agriculture is often the major source of people's livelihoods. Yet according to the Agricultural Science and Technology Indicators (ASTI) initiative, agricultural research intensity—measured as public agricultural research spending as a share of agricultural gross domestic product (GDP)—was, on average, only 0.37 percent in 2000, compared with 0.67 percent for middle-income countries and 2.35 percent for high-income countries. Nevertheless, using intensity ratios as a rule of thumb is not always appropriate because they do not take into account the policy and institutional environment within which agricultural research takes place or the broader size and structure of a country's agricultural sector and economy.

Given that appropriate, science-based technology is a key driver of agricultural growth, the low level of agricultural R&D funding is a clear threat to much-needed future agricultural innovations in Africa and other low-income countries. High food prices serve as an opportunity to increase investments in agricultural R&D so that desired increases in productivity and production become a reality.

The Innovation Systems Approach

The conventional pipeline approach to agricultural research, technology development, and dissemination has produced numerous success stories, but it has serious limitations for broad-based, sustained agricultural growth and poverty reduction because it often ignores actors such as the private sector and does not always take institutions or local knowledge and preferences into account. Broad-based, sustained agricultural growth and poverty reduction require an interactive approach to agricultural development to bring in the relevant actors, organizations, and institutions, which all play a role in this process.

The innovation systems approach is one useful paradigm for these interactions. An innovation system is a network of organizations focused on bringing new products, new processes, and new forms of organization into economic use. The system includes the interactions between these organizations and the institutions and policies that affect their behavior and performance. An innovation systems approach considers innovation as a systemic process and recognizes that innovation can emerge from many sources, complex interactions, and knowledge flows.

The innovation systems approach moves away from a traditional linear research and development model in which research is completed and results are passed on to users through extension. Instead, it emphasizes the need to nurture the demand for knowledge and technologies among a range of actors, including farmers, researchers, extension officers, policymakers, private-sector companies, entrepreneurs, agro-processors, nongovernmental agencies, and other intermediary organizations (Figure 1). The two-way flow of knowledge between these actors enables innovations to advance food and agriculture for better livelihoods for all.

To operationalize the innovation systems paradigm, the Forum for Agricultural Research in Africa (FARA) uses the Integrated Agricultural Research for Development (IAR4D) concept, which puts farmers and users at the center of innovative practices. The IAR4D encourages learning through the interchange of ideas, successes, and failures between stakeholders. The knowledge and information held by farmers and other operators in the agriculture value chain must be strengthened to enable them to operate efficiently in the knowledge economy in a way that brings about increased income and reduced poverty. Despite the appeal of the innovation systems paradigm and the associated IAR4D, it is important that studies are carried out to find out how innovations actually occur along various value chains. This will help provide guidelines for improving agricultural research and systems to disseminate appropriate new technologies.

Key Policy Options for Promoting Knowledge and Innovation for Agricultural Development

Developing-country governments face policy choices, and, with limited resources, they must make decisions carefully. Pragmatic policies and government actions can encourage actors in the food and agriculture value chain to create, accumulate, share, and use knowledge. Good policies will spur these actors to innovate, whereas bad policies discourage innovation in food and agriculture.

Farmer-centered R&D. As already stated, the evidence is clear that investment in agricultural R&D pays. Thus, as part of their poverty-reduction strategy, governments should invest in participatory agricultural research to help farmers innovate for increased productivity and production. Policy and institutional innovations can be used to motivate the private sector to undertake or finance agricultural research and to encourage commodity associations to allocate funds to research institutes or universities for commodity research. Policymakers can also provide incentives for agroprocessing firms to establish laboratories to carry out or finance food research. Other policy innovations can include competitive grant schemes to direct research into areas of immediate need or prizes for outstanding research. Organizational innovations in research organizations can include a participatory research approach that brings in all of the actors in the food and agriculture value chain.

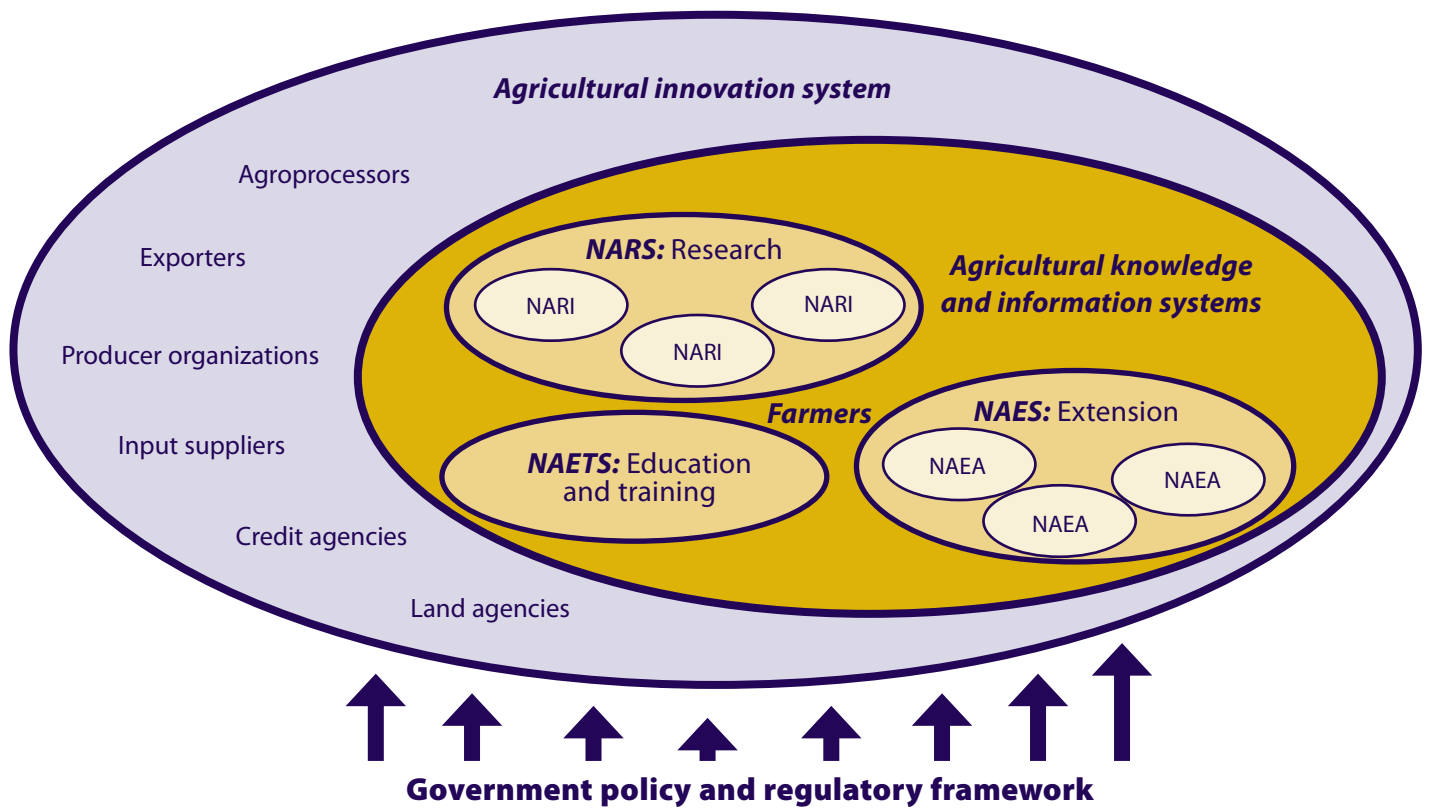
Working collaboratively, national agricultural research institutes, international research centers, farmers, and extension services have already produced numerous research results that have led to increased knowledge and innovation in agriculture. These results show the importance of focusing not just on technical, but also institutional, organizational, and policy innovations in getting research funded, organized, and implemented efficiently and getting the information shared among users to be processed for innovations.

For instance, the release of New Rice for Africa (NERICA) quadrupled rice yields in many African countries, and improved maize varieties have increased yields from less than one metric ton to more than four tons per hectare. Returns on new cotton varieties released in Senegal have been 34–37 percent. Investments in cocoa research in Nigeria led to the introduction of hybrid seed and effective control of the pests capsid (an insect) and black pod (a fungus), producing annual returns of more than 40 percent. These technical breakthroughs required adaptation to the local level. They also required changes in organization and management, as well as in policies and institutions such as markets. Nevertheless, in some cases more needs to be done to help farmers make productive use of technical innovations. Adoption of NERICA is still low. Many African farmers lack knowledge about the potential of the new rice variety or are discouraged by the additional labor it requires. Farmer adoption could be increased through innovative extension mechanisms to educate farmers and provision of affordable credit to allow farmers to hire labor.

In Kenya, the average bunch weight of bananas increased from 15–30 kilograms (kg) to more than 40 kg; a combination of factors led to this improvement. The technical aspects of tissue culture and banana-ripening boxes played a part; just as important, however, were the provision of market information and channels to producers.

Agricultural extension. Agricultural extension is an important player that can bring together research, farmers, and other players in the innovation system. Extension is defined as the services that support people engaged in agricultural production to help them solve problems and obtain knowledge, information, skills, and technologies to improve their livelihoods and well-being. Extension approaches have evolved from ministerial

Figure 1—Agricultural innovation system



Source: W. M. Rivera, G. Alex, J. Hanson, and R. Birner, Enabling agriculture: The evolution and promise of agricultural knowledge frameworks, in *Proceedings of the Association for International Agricultural and Extension Education*, AIAEE 22nd annual conference, Clearwater, Florida, USA, May, 14–19, 2006, available at <http://www.aiaee.org/2006/index.html>.

Note: NARS = national agricultural research system; NARI = national agricultural research institute; NAETS = national agricultural education and training system; NAES = national agricultural extension system; NAEA = national agricultural extension agency.

departments to national extension systems to the training-and-visit system to privatized (and otherwise reformed) systems. What matters is not so much the approach or system, but rather whether it offers a “best-fit” solution to local needs and conditions. Technologies, information, and skills that do not take users into account or do not reach users lose their desired impact.

Many farmers complain about the ineffectiveness of extension services, which are viewed as supply-driven, highly centralized, nonparticipatory systems that exclude the poor. For example, worldwide, women farmers receive only 5 percent of extension services, whereas research has shown that farm productivity increases by 22 percent when women receive the same advisory services as men. Public extension must enact technical, institutional, and organizational reforms to make it more cost-effective, demand-driven, and participatory.

Advances in information and communication technologies offer opportunities for technical changes from which both extension staff and their clientele can benefit. Mobile phones and Internet kiosks provide quick and affordable channels for relaying agricultural advice. Mobile phones can give extension staff a way to offer advice to producers who cannot read or write. A handset’s photo and video-recording functions are useful for explaining a technique and sharing other information. In Kenya, a new system that reads out text via mobile phone is helping

banana producers. This Banana Information Line, a boon to illiterate farmers, is available in Kiswahili and English and helps users troubleshoot banana cultivation problems. In Sierra Leone, mobile phones supplied by a project on ginger links agronomists and extension workers. Providing mobile phones to agronomists, extension workers, and farmers can be a cost-effective means of sharing information among these three groups.

Within extension, institutional and organizational changes are also required, so that the service goes beyond technology transfer to facilitation and beyond training to learning. It must include processes such as assisting with the formation of farmer groups, dealing with marketing issues, and partnering with a broad range of service providers and agencies.

Institutionally, extension can benefit from other organizations and processes that promote the spread of information. Informal extension, through social networks and knowledge spillovers, offers opportunities to reach farmers. Farmers meet at social functions and discuss issues of concern. They learn from each other through such interactions, and knowledge is carried from one community to another. Commodity associations and markets are also instrumental in disseminating production and marketing information to their members—the Kenya Agricultural Commodity Exchange (KACE) and the Ethiopian Commodity Exchange (ECX) are good examples.

Education and capacity strengthening. Capacity strengthening is a key policy priority for stimulating knowledge and innovation. Innovation system actors and organizations require strengthening at many levels in order to work more effectively. Farmers and farmer organizations require strengthening—for instance, establishing successful demand-driven extension services requires strengthening users' capacity to demand the types of services they need. Organizations (public sector, private sector, or civil society) that provide extension services demanded by users must also be trained to respond to users' needs. Researchers need to learn how to work with farmers and communicate with extension workers. And policymakers need to better understand the innovation system and its different components.

For decisionmakers, the key question is where to spend scarce resources on capacity strengthening: at the government level; at the level of research, education, and extension organizations; or among farmers and their organizations? Priorities depend on local conditions, such as socioeconomic level, governance structures, political system, and availability of infrastructure. All stakeholders need to participate in setting priorities.

Organizational and Institutional Innovations

Organizations and institutions that guide the performance, outcomes, and impact of the agricultural sector must be more innovative to be more efficient and effective. National research organizations, extension organizations, community and farmer-based organizations, and rural service providers within the food and agricultural value chain must be strengthened to enable them to innovate and function efficiently. To manage for impact, these organizations must be able to set long- and short-term strategic objectives, set priorities, and establish an organizational performance assessment system to guide the innovation processes they are involved in.

The institutional setting shapes the processes critical to an innovation system—that is, interactions, knowledge sharing, and continuous learning to bring about changes in a desired direction. It is important to carry out institutional analysis with respect to innovations, addressing questions that include the following:

- How do innovations come about?
- Which actors are involved in the innovation system and what roles do they play?
- What are the “rules” that guide the behavior and practices of actors?
- How are smallholders engaged in and affected by a process of institutional learning?
- What are the economics of these investments?

Actors in the food and agriculture value chain must understand the laws, regulations, traditions, customs, beliefs, norms, and nuances of society that prohibit, permit, or require certain actions. For instance, the availability of intellectual property rights promotes inventions or new ideas; security of land tenure encourages investment in land; certain belief systems tend to discount new knowledge and therefore fail to promote innovation; other customary and traditional practices may prevent societies from making progress in productivity-enhancing ventures. On the other hand, practitioners have found that some traditional institutions provide a good entry point into communities; for instance, traditional savings-and-loan groups provide a venue for promoting new technologies.

Conclusion

In a dynamic world, innovations are important to remain competitive, protect the environment, keep pace with development, and improve well-being. Innovations do not occur in a vacuum, however. They occur when innovators acquire knowledge and process it to come up with new ideas, practices, or objects that can be successfully introduced into economic or social processes.

Knowledge is central to development and likely to become more so. In the 21st century, knowledge accumulation and application will drive development processes and create unprecedented opportunities for growth and poverty reduction. Knowledge must therefore be created, accumulated, and managed to be useful for innovation. In an era of globalization and rapid change, decisionmakers should promote innovation in organizations, institutions, and policies to bring about outcomes where knowledge can be taken up, adapted, and implemented to promote development.

For further reading, see R. Birner, K. Davis, J. Pender, E. Nkonya, P. Anandajayasekeram, J. Ekboir, A. Mbabu, D. Spielman, D. Horna, and S. Benin, *From best practice to best fit: A framework for analyzing agricultural advisory services worldwide*, Inter-divisional Discussion Paper (Washington, DC: International Food Policy Research Institute, 2006); S. Fan, M. Johnson, A. Saurkar, and T. Makombe, *Investing in African agriculture to halve poverty by 2015*, IFPRI Discussion Paper 751 (Washington, DC: International Food Policy Research Institute, 2008); A. Hall, *Enhancing agricultural innovation: How to go beyond the strengthening of research systems* (Washington, DC: World Bank, Agriculture and Rural Development Department, 2007); N. M. Beintema and G. J. Stads, *Measuring agricultural R&D investments: A revised global picture*, ASTI Background Note (Washington, DC: International Food Policy Research Institute, 2008); R. Wang and J. von Braun, Fostering agricultural growth for sustainable development, *The Parliamentarian, Journal of the Parliament of the Commonwealth* 88, no. 3 (2007): 228–31.

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