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Farmer-driven research to improve food and nutrition security

This Reader was prepared by
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Context

The World Development Report (World Bank 2008) underscores the importance of growth in agriculture as a critical catalyst for economic growth and poverty reduction. The report points out that GDP growth from agriculture is shown to raise incomes of the poor 2-4 times more than GDP growth from non-agricultural activities. Sustainable agriculture plays a key role in tackling food insecurity especially in rural areas. According to the UNDP (2012b) increases in agricultural productivity and better nutrition are important for food security and human development. They argue that increased food production will increase food security by raising food availability and lowering food prices, thereby improving access to food. Agricultural production needs to increase to address unequal access to food and resources, and to meet the needs of a growing world population. It may need to increase by an estimated 70 per cent globally and by 100 per cent in developing countries by 2050 in order to keep pace with population growth and shifting diets.

The livelihood of over 60% of Africans is derived from agriculture but productivity remains low on this continent whilst all other continents have experienced significant increases. Unfortunately agricultural productivity especially in SSA has been stagnating for many years. Low levels of land and labour productivity have meant that per capita agricultural production has fallen over the last four decades. Formal agricultural research in Africa has had limited success in improving the livelihood of resource-poor farmers. A possible cause of the low impact of research in Africa could be the way research has been designed and undertaken on the continent.[1]

Many reasons have been given for the slowness of agricultural development in sub-Saharan Africa. In the first place, smallholder farmers who constitute the bulk of the farming labour, lack access to relevant technologies, and researchers have not been giving enough support to these farmers' efforts to innovate to address the diverse ecological, market, institutional and policy challenges they face. Poor infrastructural facilities lead to high transaction costs and low competitiveness of products. Farm subsidies provided to farmers in industrialised countries also play a role in creating unfavourable external markets for African farmers. This, coupled with poverty-induced ineffective internal demand for products, has put the farmers at the wrong side of the poverty belt. In addition, service provision at all stages of the commodity chain also suffers debilitating institutional weaknesses. Finally, countries in sub-Saharan Africa have very few policies and regulatory mechanisms that support the participation of local communities and the private sector in decisions on matters related to formal agricultural research and development. These technological and institutional weaknesses hinder the chances of countries in sub-Saharan Africa to enter the path of rapid economic development required to bring the farming populace out of poverty.[2]

The challenge for agriculture is threefold: to increase agricultural production, especially of nutrient-rich foods; to do so in ways which reduce inequality: and to reverse and prevent resource degradation. Science and Technology (S&T) can play a vital role in meeting these challenges — for example, by developing innovations that smallholders with limited resources can afford and use. However, they can develop such innovations only if they work in close interaction with the smallholder farmers, who are themselves innovating with the resources available to them.

2. Agricultural research: from provision of information to innovation systems

Strong science and technology system—encompassing basic, strategic, and adaptive agricultural science as well as sciences outside agriculture—is widely regarded as contributing to innovation and sustainable, equitable agricultural development. Development cannot occur without knowledge, much of which must be generated and applied nationally and often more locally. For this reason, sustaining food production and rural livelihoods while reducing poverty depends to a great extent on how successfully knowledge is generated and applied in agriculture and on whether the capacity to produce such knowledge is improved.

Aside from budgetary constraints, many public research organizations face serious institutional constraints that inhibit their effectiveness, constrain their ability to attract funds, and ultimately prevent them from functioning as a major contributor to the innovation system. The main constraints associated with many national research organizations result from strong path-dependency in institutional development and slow institutional and policy change, such as the lack of consensus on a strategic vision, ineffective leadership and management, a continued emphasis on building centralized national agricultural research structures rather than on creating partnerships, the loss of highly qualified scientific staff, and weak links with and accountability to other actors involved in innovation processes (World Bank 2005).

Over the years, research organizations have attempted to address these various constraints. Most of these efforts have centered on shifting investments away from physical infrastructure, equipment, human resource development, and operating funds and toward improvements in the management of public research organizations—for example, through better planning, improved financial management, greater accountability, and more relevant programs for clients (developed with oversight from multistakeholder boards or through better research-extension linkages).[3]

Agricultural research for development (ARD) is important for long-term food and nutrition security but only if it responds to the needs of smallholders and vulnerable, food-insecure people. Despite considerable public funding for international research over several decades in Africa, the formal ARD sector is often not producing research outcomes that bring the intended benefits to their target groups.

In the recent decades, support for agricultural development and agricultural research has been reducing, often neglecting small-scale farmers. Many bilateral donors have stopped funding agricultural research for development programmes or focus the research agenda on larger-scale and export-oriented agriculture. Only 6% of the ARD investments worldwide were spent in 80 mostly low-income countries (IAASTD 2008).

There is increasing debate on the need to revisit the organisation and approach of ARD in order to increase its effectiveness. There is generally wide agreement that, in this current process of reorienting and strategising ARD and reforming ARD institutions, the input and effective involvement of civil-society organisations (CSOs) beyond traditional researchers and private sector will be critically important in order to make ARD more relevant to food producers.[4]

For a very long time, agricultural research has largely been thought of as the domain of scientific experts, with farmers at the receiving end of the research outputs. Conventionally, in sub-Saharan Africa, ARD takes place in a linear version starting with the researcher who delivers the outputs or technologies that

are supposed to be picked by the extension services who in turn expect farmers to adopt.[5] For more than 20 years, agricultural research by national systems and international organisations has produced new varieties of cereals like sorghum and millet, and groundnuts, based on selections made in research stations. But very few varieties have been adopted by the smallholders, who continue to favour their traditional varieties. This constant failure has driven scientists to involve farmers more in the research process. However, this participation is still rather superficial because the research does not take the farmers' needs and conditions and own initiatives as starting points. [6]

During the 1980s, agricultural research focused on strengthening the research supply system at both international and country levels. During the 1990s, the focus shifted to improving the links between research, education and extension together with identifying farmers' needs for research. However, during both decades the links remained linear with research knowledge being generated for extension, which was expected to transfer new technologies to farmers. More recently the focus has changed, as it became apparent that the supply and demand for knowledge was far more complex that the linear approaches implied. It was increasingly realised that an approach involving many stakeholders was needed to speed the use of knowledge for income generation. This has come be known as an innovation systems approach. The approach embraces the totality of interactions between stakeholders required to encourage the use of research products for innovation that will benefit a wide range of actors (World Bank, 2007).

The recent evolution of agricultural research systems in developing countries has shown a change in focus from national public sector research organisations to one that emphasises a diversified public-private system, in which clients, especially farmers, are key partners in financing, planning, implementing and assessing research. Consistent with these changes, research planning, monitoring and evaluation has evolved from centrally-driven top-down approaches to give greater emphasis to decentralised and participatory approaches, in which farmer priorities and capacities are key inputs. Although some progress has been made in reforms to enhance accountability and impacts of research, these systems still face major challenges in ensuring that demand-driven approaches provide coherent research programmes consistent with national policy objectives, and in ensuring that they reflect the interests of the poor and are not captured by elites. [7]

Reviews of literature[8] on policy-relevant research and technological research and development show similar evolutions for both research processes. **These range from a linear model where research forms a step distinct from the dissemination of its products, to a model where policy formulation or research can best be understood as systemic and complex.** Ongoing interaction and feedback loops with key groups of stakeholders can help ensure the relevance of an improved agricultural input or product (whether engaging in policy-relevant research or developing technological products) and need:

- *Expertise in the innovation system*. Researchers should draw as much as possible on the wider research community, by engaging in partnerships and networks. Collaborative research projects allow researchers to draw on expertise external to the organization.

- *Policy-makers/next users.* The success of a research product will frequently hang on its uptake and acceptance by the users

of the product. Consequently, researchers must ensure that their products are adapted to users' expectations. This will involve building users' ownership and familiarity with the project through involving them in R&D activities.

- *Intended beneficiaries.* Some research disciplines within agricultural science are more suited to work in isolation than to participatory research. The challenge for these research disciplines is to allow laypeople to participate meaningfully in the decision-making processes of an organization. Drawing on the context and needs knowledge of the intended users can improve the relevance of the research, whether it is technological innovation or policy-relevant research.

- *Transparency.* Being transparent while collecting and analyzing data has both ethical and instrumental motivations. Ethically, the principle of informed consent is common to many systems, and in many research disciplines informs interactions with all research subjects. Instrumentally, clarity about the purpose of the research will increase stakeholder ownership of the research and will thus lower the risk that those involved disengage. Transparency entails that researchers explain the nature and purpose of the research, and what will be done with the information, and that they seek permission to proceed with the project.

Defining features of the three main frameworks used to promote and invest in knowledge in the agricultural sector

Defining feature	National agricultural research systems	Agricultural knowledge and information systems	Agricultural innovation systems
Actors	Research organizations	Farmer, research, extension, and education	Wide spectrum of actors
Outcome	Technology invention and transfer	Technology adoption and innovation	Different types of innovation
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	Strengthening infrastructure and human resources	Strengthening communication between actors in rural areas	Strengthening interactions between all actors; creating an enabling environment

Source: World Bank 2006.

3. Agricultural innovation

In agriculture as in other sectors, innovation is the main driver of productivity growth. In particular, public expenditures on agricultural R&D are estimated to have significant impacts on agricultural total factor productivity (TFP) growth and competitiveness (see for example Alston, 2010; Alston et al., 2010; OECD, 2011a; Fuglie, 2012).

Innovation in agriculture has been very successful in improving the productivity and quality of agricultural products, but to remain competitive, it needs to be continuous. Further innovation is needed to adapt to input and output market developments, and changes in resource quality and availability. Innovation will have a key role to play in helping the agri-food sector produce more nutritious, diverse and abundant food, and provide raw material for non-food use, without depleting natural resources, and adapt to expected changes in natural conditions from climate change.

In some regions, the challenge is to adapt agricultural production systems to more difficult natural environments (e.g. due to salinity, more frequent drought). Innovation in food industries target changes in food consumption habits linked to higher income, health concerns, higher participation of women in the labour force, and reduction of time available for meals.

3.1. What is innovation?

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.

A well-developed knowledge and innovation system has seven functions (Bergek et al., 2010):

- Knowledge development and diffusion
- Influence on direction of search and identification of opportunities
- Entrepreneurial experimentation and management of risk and uncertainty
- Market formation
- Resource mobilisation
- Legitimation
- Development of positive externalities

Types of innovation [9]

- ***Planned innovation*** includes:

A foundation stage that government supports through research and/or policy interventions, during which priority sectors and commodities are identified.

An expansion phase, where government intervenes with projects or programmes to link actors in the innovation system.

- ***Opportunity-driven innovation*** includes:

A initiation stage, where the private sector, sometimes with the support of NGOs, takes the lead, and companies or entrepreneurs identifies market opportunities.

An emergence stage, where the innovation takes off, often with rapid growth driven by the private sector, but is recognised by government and sometimes supported by NGOs.

Changing approaches in agricultural research and development

	Transfer of Technology	Farming Systems Research	Farmer Participatory Research	Innovation systems
Scope	Productivity	Input-output	Farm-based	Beyond farm gate
Changes	Farmer behaviour	Scientist's knowledge	Scientist-farmer relationship	Opening space for innovation
Institutions and politics	Technology transfer independent	Ignored	Acknowledged	Central dimension of change
Innovators	Scientists	Scientists adapt packages	Farmers and scientists	Multiple actors

Source: Scoones and Thompson (2009).

Prior to this there may be an *uncoordinated or remedial phase*, when the innovation faced stagnation or pressure to innovate further because of competition, particularly from other countries, changing consumer demands, or trade rules.

- ***Self sustaining innovation***

The ultimate phase of development for both planned and opportunity-driven innovation is a dynamic system that is neither public nor private sector led, but characterised by a high degree of public and private interaction and collaboration in planning and implementation. Such a system is agile, responding quickly to emerging challenges and opportunities and delivering economic growth in a socially inclusive and environmentally sustainable way.

Innovation was once thought of as a research-driven process. It is now recognised as an interactive process incorporating a much broader range of activities, actors, practices and policies and contexts. Together these different elements enable the creative use of both new and existing knowledge, information and technology. Since this involves the interaction of many actors with different and competing agendas, governance issues need to be addressed if innovation is going to lead to socially desirable outcomes, such as poverty reduction and environmental sustainability.

While there is no consensus on the precise nature of innovation capacity, its broad features include a combination of[10]:

- Scientific, entrepreneurial, managerial and other skills and knowledge
- Partnerships, alliances and networks linking different sources of knowledge and different areas of social, economic and policy activity
- Routines, organisational culture, and traditional practices that pattern the propensity to innovate
- Clusters of supportive policies and other incentives, governance structures and the nature of the policy process
- The ability to continuously learn how to use knowledge more effectively towards social, economic and environmental goals

However, the characteristics of the new rural economy, as well as contemporary thinking on innovation, demand that the nature of rural innovation capacity be reconsidered. This raises unexplored policy design and implementation questions. These include questions about how to create capacity that is simultaneously:

- Collective — combining expertise from different science, technology, entrepreneurial and policy domains (agriculture, health, communication, banking, etc.)
- Dynamic — evolutionary and able to respond to rapidly-changing contexts (technical, market, policy, political and social)
- Systemic — addressing the challenges and opportunities emanating from the interconnectedness of different spheres of rural and global activity
- Opportunistic — taking advantage of knowledge convergence in apparently unrelated fields
- Sensitive — tackling social, economic and environmental concerns in an integrated fashion

3.2. Innovation systems and agricultural innovations systems

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.

Source: World Bank 2006.

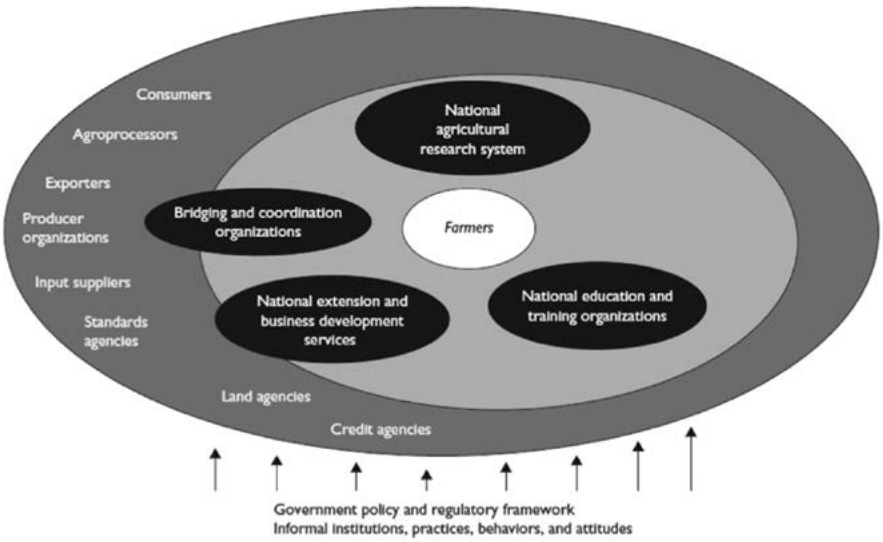
An Innovation systems involve different actors working and learning together in various forms of multi-stakeholder, dialogue and learning alliance processes. To be effective, these processes require good knowledge and research support, effective brokering and facilitation and capacity development of the individuals and organizations involved. There also remains much to be learned about how to enable and support such processes in different contexts and around different thematic issues.

Capacity development is also an important aspect of developing effective innovation systems. The pace of change and complexity of issues demands that individuals and organisations need to be constantly and rapidly updating and improving their capacities. There is a vast need for focused, need driven and inter-disciplinary capacity development that complements traditional forms of graduate and postgraduate education. Such capacity development goes beyond 'training' to involve longer term processes of engagement, on-the-job facilitated learning and the support of various forms of cross-organisation and cross disciplinary learning alliances.

An **Agricultural Innovation System (AIS)** approach looks at the multiple conditions and relationships that promote innovation in agriculture. It may offer a more flexible means of dealing with the varied conditions and contexts in which innovation must occur. It considers the diverse actors involved, their potential inter - actions, the role of informal practices in promoting innovation, and the agricultural policy context.

An AIS is a collaborative arrangement bringing together several organi-zations working toward technological, managerial, organizational, and institutional change in agriculture. Such a system may include the traditional sources of innovations (indigenous technical knowledge); the modern actors (NARIs, international agricultural research institutes, and advanced research institutes); private sectors, including (local, national, and multinationals) agro-industrial firms and entrepreneurs; civil society organizations (NGOs, farmers and consumer organizations, and pressure groups); and those institutions (laws, regulations, beliefs, customs, and norms) that affect the process by which innovations are developed and delivered.

An Agricultural innovation system



Source: Modified from Rivera et al. n.d.

The AIS principles of analysis and action integrate the more traditional interventions (support for research, extension, and education and creation of links among research, extension, and farmers) with the other complementary interventions needed for innovation to take place. Such interventions include providing the professional skills, incentives, and resources to develop partnerships and businesses; improving knowledge flows; and ensuring that the conditions that enable actors to innovate are in place.[11]

The first signs of a 'systems' approach towards agricultural technology development and dissemination were the emergence of **Farming Systems Research (FSR) and Agricultural Knowledge and Information Systems (AKIS).**

The FSR concept dates back to the 1970s, and was articulated in response to the growing acknowledgement that research efforts had to be framed by the particular farm-level contexts in which impacts were expected. Thus, FSR developed into a largely extractive and diagnostic framework. However, by the 1980s, FSR had established itself as an isolated discipline alongside other agricultural subjects. Throughout the 1980s, calls were being made to address the isolation and narrowness of FSR by firstly, equipping all agricultural researchers with an appreciation of the farming systems context in which their work would be applied, and secondly, by taking FSR beyond its extractive, information gathering role. Gradually, variations of the 'basic' FSR approach started to emerge mainly concerned with extension and training. These

developments coincided with the **'farmer first'-concept**, through which farmer innovation and the notion of integrating farmers' and scientists' expertise began to gain prominence.[12]

The articulation of the **Agricultural Knowledge and Innovation systems (AKIS)** in the late 1980s broadened the range of actors to include agricultural education organisations who were seen as playing a role in rural innovation. Moreover, the development of AKIS was a turning point for the extension field, situating traditional extension practice into a wider system. It was a normative model, presenting what an ideal agricultural knowledge system should look like. However, the key lesson from much of AKIS work was that reality rarely coincided with the model, leading to attempts to understand the reasons behind such incompatibility. This led to the evolution of methodologies, such as **Rapid Appraisal of Agricultural Knowledge Systems (RAAKS)**,[13] which aimed at providing stakeholders with a systems-like outlook towards their activities. RAAKS-methodology is useful since it brings stakeholders together and provides them with the necessary tools to analyse and reflect upon their own system, and to propose ways of improving it. However, as with many reflexive methodologies, difficulties arose with attempting to institutionalise and implement these proposals. RAAKS is one of a large range of participatory approaches that emerged in the 1990s and attempted to realise the synergistic potential of AKIS. However, many of these approaches have subsequently come under scrutiny over the true extent of equitable participation promoted by them.

While the emergence of a systemic approach towards understanding knowledge-based rural change can be traced back to notions of FSR, AKIS and participatory research, and have been discussed at length in previous literature,[14] these are only briefly mentioned here. The aim of the current exercise is to explore how different schools of thought are building on these earlier perspectives and incorporating new ideas and perspectives.

Interpretations of Systems perspectives

Systems perspectives is a widely-used term to describe contemporary research efforts in rural change. Overall, 'innovations' are understood as complex socio-technical arrangements. There is broad recognition that the process of innovation involves interactive learning (some refer to it specifically as 'social learning') and multiple sources of knowledge. Similarly most systems studies recognise that innovation processes are embedded in particular social, historical, market and political contexts. Understanding and/ or trying to influence institutional dimensions of innovation ('attitudinal change') is receiving much attention. However, there are also some subtle differences in definitions of 'systems perspectives on rural innovation', which reflect the various focii of research groups. In other words differences are often related to the particular views of the boundaries of the system, its key actors and processes. Some concentrate on the role of communication within the new innovation environment; others focus on the role of farmer innovation and expertise therein; while others still deliberate the roles of traditional Agricultural Research and Development (ARD) institutions in such a setting.[15]

Maija Hirvonen[16] identified six distinctly different, although overlapping schools of thought on this topic.

- The social learning and communications school, with its roots in agricultural extension and pioneered by the Wageningen group;
- The local innovation processes/ farmers knowledge school, a very wide category with its roots in the Farmer First movement and championed by, among many others, by PROLINOVA.
- The science and society school with IDS as a leading player;
- The institutional learning and change (ILAC) school
- The agricultural innovation systems school;
- The market systems and innovation school, championed by KIT, CIAT, and CIP/ Papa Andean/ Condesan in Latin America.

Commodity-Based Innovation Systems

A commodity-based innovation system incorporates the various actors, their actions and interactions, as well as the enabling environment, facilitating institutions, and services that condition the various forms of innovation along the value chain of that commodity (Figure 3). This emphasizes the notion that innovation can occur anywhere along

the value chain, not necessarily at the farm level, thus broadening the research agenda to incorporate both biophysical and socioeconomic research within the research for development portfolio.

The Participatory market chain approach and innovation17

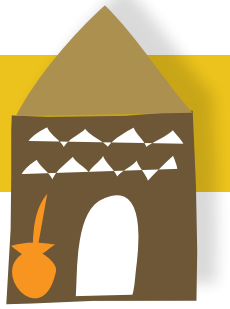
Enterprises and value chains are implicitly embedded in an innovation system. Market processes and innovation systems are mutually embedded, and it is not possible to have one without the other. Innovation systems are not an alternative to the market process. Markets are part of the necessary, adaptive link between innovation and development, but they are not sufficient of themselves; other instituted activities, such as education, research, and service delivery, all matter. The value chain concept enables the incorporation of backward and forward linkages, and the realization of the entire contribution of a particular sector or commodity to the overall economy. It also allows issues beyond the farm boundaries to be addressed. Innovation is perceived as a continuous learning process in which individuals/groups/organizations/ firms master and implement the design, production, and marketing of goods and services that are new to them, although not necessarily new to their colleagues or competitors, whether domestic or foreign (Metcalfe and Ramlogan 2008). Innovation can occur anywhere along the value chain and can be of different types. In practice innovation systems are constructed to solve "local" real world problems using a value chain approach. The diagnostic process allows priority problems to be addressed anywhere along the value chain, and an innovation system can be constructed around these problems. To facilitate the effective integration of VCA and ISP in participatory IAR4D processes, the capacity of all stakeholders along the value chain needs to be enhanced, and the necessary policy and institutional environments need to be created. The innovation capacity of the value chain, the ability of chain actors to innovate as a group and respond to changing consumer demands is, therefore, a sum total of the individual innovation capacity of the actors in the different stages of the value chain. Successful dynamic improvement in value chain performance critically depends on the ability of the chain actors to acquire, absorb, disseminate, and apply new technological, organizational, and institutional inventions continuously. This is a challenge facing R&D practitioners and policymakers.[18]

Food systems are evolving rapidly in developing countries. Supermarkets and sales of packaged food are expanding fast, impacting on production and the marketing practices and livelihoods of small farmers. There is a new consensus that agricultural research and development (R&D) should help small farmers link up with profitable markets.

The emergence of **market-driven innovation** has been reported in many recent surveys of innovation in Africa (e.g. Adekunle et al., 2012). Market innovation takes place through different channels: emergence of new value-chain arrangements, the taking into account by producers of a consumer or industry demand or standard. There is also the more traditional yet still critical issue of access to inputs. Most of the market-related cases combine elements of technical innovation with organizational or institutional ones. While linking to the markets is increasingly considered vital for improving smallholders' livelihoods, accessing markets for products, inputs or capital is not straightforward for them, as it implies tangible risks and requires collective action, which itself usually requires significant support from other stakeholders.[19]

3.3. Integrated agriculture research for development (IAR4D)

The Forum for Agricultural Research in Africa (FARA) has promoted the **integrated agriculture research for development (IAR4D)** approach based on an innovation systems framework. This brings together multiple actors along a commodity value chain to address challenges and identify opportunities to generate innovation. The approach creates a network of stakeholders or partners who are able to consider the technical, economic, social, institutional, and policy constraints in an environment. The network facilitates research and learning that not only generates new knowledge, products or technologies, but also ensures the use of research products. The IAR4D approach is being tested at three pilot research sites across SSA: in Eastern and Central Africa around Lake Kivu (Democratic Republic of Congo, Rwanda and Uganda); Southern



Africa (Malawi, Mozambique and Zimbabwe); and West Africa (Niger and Nigeria). This has involved the establishment of 36 stakeholder innovation platforms thus: creating functional linkages between farmers, the private sector, and service organizations; integrating productivity, natural resource management, markets and policy; establishing effective mechanisms for organizing and learning processes for farmers; and ensuring action research oriented toward problem-solving and impact.[20]

Research activities are geared towards answering three central questions aimed at the proof of the concept: (i) Does the IAR4D concept work and can it generate deliverable international and regional public goods for the end users? (ii) Does the IAR4D framework deliver more benefits to end users than conventional approaches (had the conventional R & D and extension approach had access to the same resources)? (iii) How sustainable and useable is the IAR4D approach outside the test environment (i.e. issues of scaling out for broader impact)?

Innovation systems approaches are often based on commodity value chains in which knowledge and/or research products with purchased and farm- or household-provided inputs are: used in natural resource based production systems; marketed and processed for sale and consumed. Inevitably this involves many actors in the supply chain from producer to consumer. Interventions to support an innovation vary with purpose and are influenced by both the initial context and the capacity of different stakeholders. Typically an intervention to support innovation requires a phased approach from initial engagement with stakeholders, through planning, implementation, learning and assessment to a final phase that ensures continuity and sustainability within a dynamic innovation environment.[21]

The use of innovations systems approaches are now expanding rapidly, with donors, international and regional organisations, national governments, and non-governmental organisations (NGOs) increasingly seeking to promote stakeholder partnerships involving both public and private sectors in supporting agricultural development.[22]

For instance, the country-level support provided by the Common Market for Eastern and Southern Africa (COMESA) through the Comprehensive Africa Agricultural Development Programme (CAADP), for the planning and implementation of national Agricultural Sector-Wide Programmes (ASWAps) is based on key national stakeholders from the public, private and NGO sectors agreeing a strategy and working together in its implementation. This requires a clear process for stakeholder interaction that can be seen as a 'National Coordinating Innovation Platform'. Many donors are supporting such processes and are increasingly encouraging value-chain approaches that stimulate stakeholder participation, so that systems constraints can be identified and opportunities to work together in finding solution found.

UK's Department for International Development (DFID)-funded **Research-Into-Use (RIU)** programme that covers a number of African and Asian countries is based on encouraging an innovations systems approach.

3.4. How agricultural innovation happens?

There is widespread agreement that the outcomes of science and technology-related development interventions have varied over geographical regions and socio-economic groups. Raising awareness of farmer innovativeness, and creating methodologies for participatory research are examples of ways through which a more level playing field has been promoted. However, such approaches on their own are unlikely to lead to a more equitable distribution of benefits. Instead, it is necessary to connect them with the wider contexts in which they are situated by acknowledging the fact that no development interventions — with or without a science and technology dimension — take place in political, economic, social, cultural or institutional vacuums.

Agricultural innovation typically arises through dynamic interaction among the multitude of actors involved in growing, processing, packaging, distributing, and consuming or otherwise using agricultural products. These actors represent quite disparate perspectives and skills, such as metrology, safety standards, molecular genetics, intellectual property, food chemistry, resource economics, logistics, slash-and-burn farming, land rights—the list is far too long to complete here.

Farmer-driven research to improve food and nutrition security

For innovation to occur, interactions among these diverse stakeholders need to be open and to draw upon the most appropriate available knowledge. Aside from a strong capacity in R&D, the ability to innovate is often related to collective action, coordination, the exchange of knowledge among diverse actors, the incentives and resources available to form partnerships and develop businesses, and conditions that make it possible for farmers or entrepreneurs to use the innovations. Box O.3 provides examples of how innovation has occurred in agriculture.[23]

The findings of the World Bank Study on Agricultural Innovation Systems [24] include some interesting features:

- Innovation is rarely triggered by agricultural research and, instead, is most often a response of entrepreneurs to new and changing market opportunities.
- Promising sectors begin to fail because with everchanging market demands, patterns of interaction between entrepreneurs, farmers and other sources of technology and information are insufficient to support a knowledge-intensive process of innovation on a continuous basis.
- Lack of interaction weakens innovation capacity and is a reflection of deep-rooted habits and practices in both public and private sector organisations.
- The market is not sufficient to promote interaction; the public sector has a central role to play.
- Social and environmental sustainability are integral to economic success and need to be reflected in patterns of participation and interaction that are considered when strengthening innovation capacity.
- Mechanisms at the sector level that are critical for coordinating the interaction needed for innovation are either overlooked or missing.

The study made two recommendations which have become very familiar:

- A major shift in interventions away from supporting agricultural research and with a new focus on strengthening patterns of interaction across the whole range of actors involved in innovation.
- A priority within this new focus is to find ways of developing and adapting habits and practices that foster a capacity to innovate, which integrates pro-poor and pro-market agendas.

Innovation triggers are fairly diverse : degradation of natural resources (e.g. declining soil fertility, or a dwindling supply of water, a disappearing forest), is among the most common; seizing a local or global market opportunity, introducing a new, improved technology or practice (improved breed of livestock, a new way of parboiling rice, a fertility-improving input). Changes in policy are rarely mentioned.

4. Drivers of success for innovation

4.1. A multiplicity of factors

The case studies analysed by FARA[25] 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.

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 compliment specialist technical expertise.

- IAR4D and innovation systems approaches can support New Partnerships for Africa's Development (NEPAD)'s Comprehensive Africa Agricultural Development Programme (CAADP) country processes.

4.2. Building alliances and networks of innovation

AIS involve a wide range of actors, who guide, support, create, transfer or adopt innovation, and who advise and inform farmers and the public about innovations. Governments provide strategic guidance, financial support to researchers and advisors in public and private organisations, and research infrastructure such as databases, laboratories and information and communication technologies (ICT).

They also implement policies and regulations that affect the business and innovation environment, for example investment support, tax policy, agricultural and rural policies, and labour, consumer and environmental regulations. Researchers, private businesses and farmers create innovations. Advisors and other intermediaries (brokers, credit institutions, input suppliers) help diffuse innovation in farms and agrifood firms. Charities and non-governmental organisations (NGOs) play a role in funding innovation, and providing information and advice. Finally, markets and consumers provide signals on demand for innovation and acceptance of supplied innovation. All actors are involved to some extent in the provision of information. [26]

The focus on constructing partnerships and networks of innovation, where evolving communities – of farmers, scientists and others – work together towards a common goal should be promoted.

Typical public and private sector actors involved in innovation

Level	Pivotal actors driving innovation		
	Public/NGO sector	Private sector	
		Commercial sector	Farmer representatives
International and Regional	Donors CGIAR research centres FAO, SROs, NGOs	International input and output marketing companies	
National[1]	MoA (Research, Extension) NGOs	Input supply companies Wholesalers Processors Supermarkets, hotels Representative associations	Farmer unions National farmer associations
District or Local Government	District/ Local Government councils District Agricultural Officers (DAOs) Local research Schools, hospitals NGOs/projects[2]	Agri-dealers Transporters Traders Processors	Farmer associations or cooperatives
Community	DAO Extension staff		Farmer groups or clubs Individual farming households

1. National actors are often linked to regional or international initiatives
2. Donors and NGOs often support either or both public or private sectors

Source: Adekunle AA, Ellis-Jones J, Ajibefun I, Nyikal RA, Bangali S, Fatunbi O and Ange A.2012. Agricultural innovation in sub-Saharan Africa: experiences from multiple-stakeholderapproaches. Forum for Agricultural Research in Africa (FARA), Accra, Ghana.

Remarking on **the diversity of stakeholders** involved in innovation has become fairly common place, especially in the wake of IS approaches (e.g. Hounkounou et al., 2012). The typical stakeholder list for a given inventory case includes a mix of individual farmers-innovators, one or several community-based or farmer organizations, formal research, extension services, NGOs, private entrepreneurs, government, etc. Externally-funded R&D projects also appear as major stakeholders in many inventory cases (see below). Depending on the specific case and also on the phase of innovation, **lead and active stakeholders** vary. For instance, research, an NGO or a R&D project might be very active in initial stages (conducting diagnosis and on-farm experimentation, providing capacity-building, etc.), while farmers and their organizations, or a business stakeholder become more active in subsequent phases. Interestingly, while usually present and active, research does not necessarily appear to play a leading role or to be the initiator of innovation in many inventory cases, as ideas and initiatives come from different sources, including the farmers themselves. Conversely, decision and policy-makers, and to a lesser extent private sector organizations hardly appeared among the active stakeholders of JOLISAA inventory cases. This might reflects the relative scarcity of specific pro-innovation public policies in the countries under study, as well as a relative weakness of the inventory framework about such dimensions. It also reflects the limited connections of national teams with what still remains for them non-conventional partners. The inventory also shows that there are many different ways of organizing the **interactions among stakeholders**: in some cases, interactions remain rather informal, while in others, they take place under the umbrella of a R&D project. They can also take the form of a multi-stakeholder platform, especially when a common resource (e.g. a mangrove, an irrigation scheme, a forest) needs to be managed (Hounkounou et al., 2012) or when such a platform is organized under the umbrella of a project. In many inventory cases, one of the stakeholders (typically a research institute, an NGO), usually plays the role of intermediary (Klerkx and Leeuwis, 2008) to facilitate interactions among stakeholders.[27]

The clue to radical innovation is cooperation between actors. Cooperation and establishing formalized partnerships becomes more critical as an innovation evolves.

Engaging with the private sector is critical. With R&D systems – from seeds, to fertilisers, to chemicals to information and advice – increasingly owned and controlled by private sector players, often in highly vertically-integrated and consolidated large businesses, negotiating relationships with the private sector is key. Whether this is around gaining access to private

sector skills and expertise in high-end technology development, or privately held intellectual property rights over products or processes, a Farmer First approach for the 21st century must address these questions head on.

One of the currently favoured approaches is the plea to develop **public-private partnerships (PPPs)** which include very diverse arrangements, including partnerships for resourcing, contracting, commercialising, frontier research and value chain development. These may address different problems from investing in new innovation pathways to ensuring access to proprietary technologies, to leveraging private sector skills and reach in service delivery and cost reduction to. And they may involve dealing with large transnational companies or whole networks of very small private sector operations.

For an innovation system to be effective, the capacity of its diverse actors must be built and strengthened. To enhance innovation capacity, it is necessary to invest in learning and capacity building, provide incentives that allow actors to put new skills into use, and also nurture new attitudes and practices. Programs that encourage greater openness in organizations to collaborating with diverse formal and informal actors, introduce organizational and managerial innovations within organizations, or strengthen individual and organizational incentives to develop innovative capacity, should be promoted. The organizational or collective innovative capabilities, however, reside in individuals, in the information and technology used by an organization, and in an organization's structure, routines, and coordination methods. Besides nurturing individuals who act as change agents within organizations, the case studies highlight the power of: collective action within and among organizations; flexibility (to allow self-organization); building self-confidence and trust; fostering preparedness for change; stimulating creativity; and the enabling environment, particularly the policy and funding incentives that permit these characteristics to develop. Policy capacity thus needs to be strengthened to build innovation capacity.[28]

Investing in Innovation Capacity

An agenda for strengthening innovation capacity should focus on building networks of interaction and learning that will enable new and existing knowledge to be used. Building these networks will require either coordination or the provision of strong incentives and help for self-organization. Institutional and policy change are typically at the heart of innovation capacity development, particularly in the long term. As the context changes and the actors and needs evolve, it is important to build adaptive capacity and retain flexibility.

While it is impossible to be definitive about what a context-specific and adaptive capacity for agricultural innovation might entail, some broad elements can be described:

- A *national culture that appreciates the value of scientific knowledge* in enterprise and development. It is important to advocate for such a culture and enhance it.

- A *critical mass of scientists*, trained in frontier areas of science, who are supported by sufficient *infrastructure* and *funding* to be employed productively in research and development in the public and private sectors.

- Appropriate *training organizations*, including universities, which are engaged and strengthened to create this human capital.

- *Appreciation and engagement of a range of actors* with different types of agricultural knowledge, codified and tacit, in the public, private, and nongovernmental sectors.

- *Linkages* between key sources of knowledge and the social capital that permits new linkages to be brought into play when needed. It is crucial to initiate and sustain relationships and institutions (including habits and practices) that support dialogue, knowledge access, sharing, and learning between different sources of knowledge, between different interest groups, and between policy actors, practitioners, and researchers.[29]

4.3. The increasing use if ICTs

The role of information and communications technology (ICT) in producing and disseminating knowledge has expanded exponentially. ICTs offer striking opportunities to change how agricultural science, innovation, and development occur by enabling a variety of stakeholders to interact and collaborate in new ways to enhance the innovation process.

Farmer-driven research to improve food and nutrition security

ICTs offer the opportunity to improve knowledge flows among knowledge producers, disseminators, and users and, for example, among network partners; support the opening up of the research process to interaction and more accessible knowledge use; and more cost-effectively widen the participation of stakeholders in the innovation and governance process. ICTs have more often been associated with providing advanced services to number crunching and data management, geospatial applications, knowledge-based systems and robotics, and improved farm equipment and processes, but less often been considered for connecting diverse innovation communities—whether at the local, subsectoral, and national level.

ICTs that serve as information "collectors," "analyzers," "sharers," and "disseminators" are already positively affecting agricultural interventions in developing countries. Affordable mobile applications, in particular, provide linkages to previously isolated actors: information on prices, good farming practices, soil fertility, pest or disease outbreaks, and extreme weather has expanded farmers' opportunities to capitalize on markets, react to unfavorable agricultural conditions more effectively, and better interact with public service agents. Satellite imagery and aerial photography have increased the capacity of scientists, researchers, and even insurance providers to study farm conditions in remote areas and assess damage from climatic challenges like drought. Increasingly affordable technologies like radio frequency identification tags and other wireless devices are improving livestock management, allowing producers to monitor animal health and trace animal products through the supply chain. A persistent barrier to innovation, the lack of rural finance, is also lifted by digital tools.[30]

Mobile phones are becoming pervasive in some rural areas. They are more than a mechanism for two-way flows of information. Kenyan farmers use them to obtain market prices, verify the certification of seed and fertilizer sellers, and obtain recommendations on which fertilizer and seed to choose. Equipped with GPS and cameras, mobile phones are becoming a very efficient means for researchers and farmers to collect farm-level information. For example, a network of sentinel farmers in the Great Lakes region of Africa monitors two cassava disease pandemics, the hybridized form of cassava mosaic virus and two species of cassava brown streak virus. A data template has been developed with the service provider, and farmers provide photographs of suspected new outbreaks. This effort could evolve into an interactive disease surveillance and control system. The potential of mobile phones for such interactive information flows between researchers and farmers will continue to evolve.[31]

4.4. Rethinking agricultural education

Agricultural extension and advisory services

Like R&D, agricultural extension and advisory services have passed through various cycles of challenge and reform. The field of extension has evolved rapidly in the last 20 years. The public services that dominated extension services suffered limited funding, insufficient technology, poorly trained staff, weak links to research, and limited farmer participation. Because previous approaches have been ineffective, most extension programs are moving away from centralized systems and trying to improve links with research and farmers. Most programs widely acknowledge the need to build social capital among farmers, pay greater attention to the needs of women and youth, and facilitate better links to markets. Despite widespread agreement on the need for change, it is clear that no single extension model is universally relevant. New models need to be developed, based not only on general principles but also on analyses of the specific farming systems and social conditions they are expected to address. [32]

Education and training institutions are especially significant in an AIS because they develop human resources and at the same time serve as a source of knowledge and technology. The absence or decline of these institutions leaves a large gap in a country's innovation capacity. Even so, government and donor investments in agricultural education and training (AET) have dropped to almost nothing since the early 1990s (World Bank 2008).

For AET, the primary constraintis that institutions have not kept pace with the labor market's demand for knowledge and practical competencies, especially in agribusiness, business and program management, and the problem-solving and interpersonal skills crucial for actors to function in an

AIS. Despite this poor performance, global experience shows that it is possible to build productive and financially sustainable education systems (World Bank 2007b).

Farmers must now contend with multiple sources of information, advice and service support and need different mode of delivery. No longer are extension workers restricted to farmer training sessions and demonstration plots (although these are still important), but joint-learning sessions to understand core principles (as in Farmer Field Schools) or field experimentation in farmer-led trial processes have opened up significant opportunities for more open-ended, non-directed learning. And this is enhanced significantly by the application of new media and information technologies – near ubiquitous cell phones and text messages can become important routes for transferring information for real-time market information, GIS systems and satellite information can provide site-location support, mobile testing systems can enhance diagnostics of soils, pests and diseases, and video technology and rural radio/TV can encourage exchange of ideas and views in ways not possible, or even thought about, 20 years ago.[33]

Organisational and policy change is required within educational systems as a whole.[34] New forms of curricula are also needed. This may require introduction of a participatory curriculum development methodology guided by insights from modern adult teaching and learning theory and practice. Efforts need to be invested in helping faculty to change teaching/learning methods and styles. This requires incentives and sensitive facilitation. Professional rewards and hierarchies need reform to encourage and validate Farmer First ways of doing things. This is likely to incentives, awards and other forms of recognition, as well as support mechanisms and mentoring to encourage younger professionals.

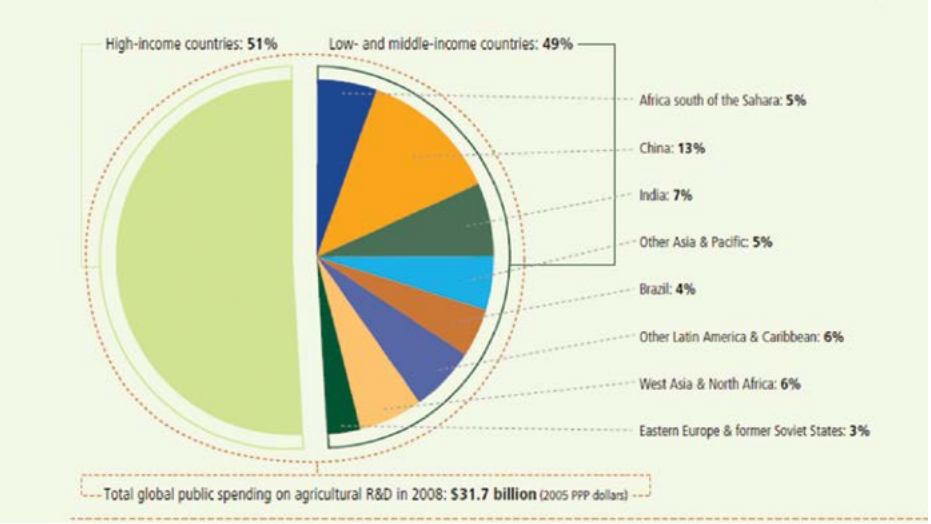
Options for providing and financing pluralistic agricultural advisory serices

	Finance provider				
Service provider	Public sector	Private sector: Farmers	Private sector: Companies	Third sector: NGOs	Third sector: Farmer-based organizations (FBO
Public sector	Public advisory services (different degrees of decentralization)	Fee-based public advisory services	Private companies contract staff from public advisory services	NGOs contract staff from public advisory services	FBOs contract staff from public advisory servic
Private sector: Companies	Publicly funded contracts to private service providers	Private companies provide fee-based advisory services	Embedded services: Companies provide information with input sale or marketing of products	NGOs contract staff from private service providers	FBOs contract staff from private service providers
Third sector: NGOs	Publicly funded contracts to NGO providers	Advisory service staff hired by NGO, farmers pay fees	Private companies contract NGO staff to provide advisory services	NGOs hire own advisory staff and provide services free of charge	
Third sector: FBOs	Publicly funded contracts to FBO providers	Advisory service staff hired by FBO, farmers pay fees		NGOs fund advisory service staff who are employed by FBO	FBOs hire own advisory staff and provide services free to members

Source: Birner et al. 2009, adapted from Anderson and Feder (2004,44).

4.5. New ways to fund local R&D

Global public spending on agricultural R&D by major country or region and by income status, 2008



Source: ASTI 2012, Eurostat 2012, and various country-level secondary resources.

Financing agricultural research and Development

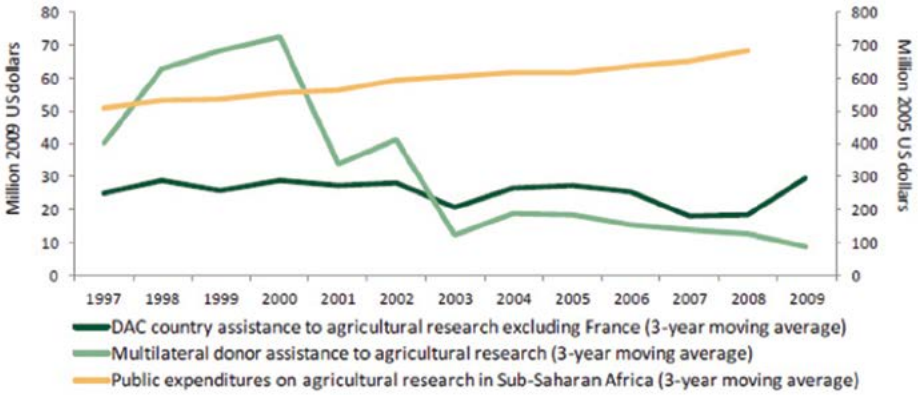
During the past 50 years, agricultural science in many developing countries has benefited greatly from support from industrialized countries. Donors have provided financial support to national agricultural research systems, supported scientific training at foreign universities, organized in-country training programs, allocated staff to assist in training and research, and helped develop an international architecture that facilitates the movement of knowledge and materials for agricultural research and development (R&D). Donor support was withdrawn in many countries due to concerns over inefficient and competition for funding with health, education, and other social-sector investments, and because of complacency over high global food surpluses and low commodity prices (Christensen 1994; World Bank 2008). Recent analysis shows that public investments in agriculture and agricultural R&D in many Sub-Saharan African countries have started to move away from crisis. New commitments from governments and foreign donors over the past decade have put agriculture back on the agenda and attracted new resources to the task, sizable portions of which have been channelled to Sub-Saharan Africa. Unfortunately, the quality of data on levels and trends in donor funding makes it difficult to analyze these changes precisely: estimates of donor funding for agricultural R&D in Sub-Saharan Africa vary widely. The Organisation for Economic Co-operation and Development (OECD 2011) estimates commitments (not disbursements) for 2009 at just $67.1 million (in constant 2009 prices), inclusive of bilateral (the Development Assistance Committee [DAC]) and multilateral assistance. However, the OECD estimates omit commitments from private donors, such as the Bill and Melinda Gates Foundation (BMGF). A study by Morton (2010) estimates donor funding for agricultural R&D in Sub-Saharan Africa in 2009 at approximately $450 million. Coppard (2010) places the 2008 figure at about $245.6 million (in constant 2007 prices).

These gains were partly the result of traditional donors returning to agriculture during the first decade of the new millennium, but they were also the result of new donors entering the landscape. Renewed, expanded, and more diversified funding contributed much to this increase in public expenditure on agricultural R&D in Sub-Saharan Africa and other developing regions.

Nonetheless, donor funding to agricultural R&D in Africa remains tenuous at best. Funding still tends to be fairly volatile from year to year and uncoordinated among donors at regional and national levels.[35]

Farmer-driven research to improve food and nutrition security

Selected donor commitments and governments spending on agricultural research in Sub-Saharan Africa 1997-2009



Source: Spielman David J., Zaidi F. and Flaherty K., based on data from OECD (2011) and Beintema and Stads (2011)

Note: Development Assistance Committee (DAC) and multilateral assistance to agricultural research are measured on the left-hand scale; public expenditures on agricultural research are measured on the right-hand scale. DAC country assistance figures do not include France due to unexplained discrepancies in OECD data, which record official development assistance to agricultural research as climbing steadily from US$7.3 million in 1995 to US$63.5 in 2006, followed by a massive increase to US$297.6 in 2007 before dropping to US$29.9 in 2008 (all in nominal terms). OECD's multilateral donor trend does not include the African Development Bank and the International Bank for Reconstruction and Development.

Investments in R&D, including research and advisory services, have been the World Bank's major strategy to improve agricultural productivity and innovation (World Bank 2009b). The World Bank alone invested US$4.9 billion (US$5.4 billion in real million dollars, 2010 = 100) into agricultural R&D and advisory services over the 20 years from 1990 to 2010. The World Bank's annual commitments to agricultural research, extension, education, and training have ranged from US$100 million to US$800 million. The very low commitments by governments and donors to agricultural tertiary education since the early 1990s are an especially worrying trend (World Bank 2007a), because they imply that a capacity for innovation is not being sustained.[36]

Financing farmer-led research

One key way to assure that control remains with the farmers is to give them access to resources for funding research they regard as important. In eight countries in Africa and Asia, FAIR (Farmer Access to Innovation Resources) is piloting Local Innovation Support Funds (LISFs) for farmer-led joint research and innovation managed by local organisations. Men and women farmers and groups propose research projects. The local fund management committee selects those to be supported. The funds are used to buy materials for the farmer-led research, to pay supporting specialists (scientists or others) or to obtain relevant information. This mechanism turns conventional research funding on its head. It will be a sign that farmer-led joint research is truly mainstreamed when part of the government budget for ARD is allocated to such community-managed innovation funds.[37]

Lessons from practice

- Farmer-led joint research is an experiment with a new way of working that is unfamiliar to all partners, also farmers. Past experience has led to certain habits and expectations in interactions between farmers and other ARD actors. There is need for trial and error, reflection and honest assessment of what happened, until people learn to interact as genuine partners in ARD – especially until farmers with less formal education gain the skills and confidence to assert themselves in communication with formally educated scientists.

- The innovations that farmers develop may seem very simple but this should not prevent other ARD

- stakeholders from engaging with farmers in joint research. As in the Nepal case (see box) outputs of joint research on the simplest of innovations have been readily taken up by other farmers, leading to positive livelihood impacts.

- Simplicity of experimental design and visual assessment are characteristic of farmers' research.

Establishing competitive funding mechanisms that involve key stakeholders, especially users, in promoting demand-driven research, setting priorities, formulating projects, and screening proposals should be further explored.

Joint research

Starting with local innovation provides an entry point for joint research embedded in local realities and driven by farmers' interest. Discovering how and why farmers innovate makes outsiders appreciate what local people are already trying to do to improve their situation. Also the farmers start to see themselves differently: although often poor in terms of financial resources and formal education, they realise they are rich in knowledge and ideas. A sound basis is laid for true partnership, in which the different contributions of the partners are equally valued.[38]

Joint research encompasses a variety of activities. It could be a trial conducted by farmers and extensionists (and maybe scientists) to find out which botanical substances are most effective in controlling diseases in animals or crops. It could be collaboration with a mechanic or engineer to make an implement easier to use or more efficient. It could involve working with private enterprises or consumer organisations in exploring processing and marketing procedures to see how benefits along the value chain can be more fairly divided. It could be working with communication experts to try out new ways of sharing information about agriculture. Thus, the focus could be on "hard" (technologies) or "soft" innovations (changes in institutions or methods) that farmers have chosen to investigate and for which they draw in other supporting expertise. In all cases, the research is led by farmers, with the support of other ARD actors.[39]

5. Local innovation processes: successes and lessons learned

The instances of agricultural innovation listed here came about in different ways. In some cases, markets heightened the pressure to innovate, and the private sector played a decisive role in driving the subsequent innovation. In others, public sector interventions, such as policy, R&D, and other incentives, drove the innovation process.

Convergence of Sciences

Strengthening agricultural innovation systems in Benin, Ghana and Mali' (CoS-SIS) aims to unlock the potential of smallholder farming in West Africa by creating enabling conditions for farmers to innovate. Since 2002, the programme has been experimenting with this approach, which takes a different track to mainstream research. Rather than focusing on technical innovations, CoS-SIS helps national, sub-regional and African agricultural research organisations, universities and other public and private sector agencies, including non-governmental organisations (NGOs), to strengthen their programmes. It supports university curriculum development and informs decision makers at district and national levels about ways to encourage smallholder innovation. CoS-SIS has developed from a first phase (2001–2006) that focused on participatory technology development.[40]

The studies indicate that the bottleneck in West African agriculture is not so much the lack of innovation and productivity at the farm level, but their lack *within* the very small windows of opportunity that currently exist to improve farmers' livelihoods. These windows can be expanded to allow room for innovation and change by ensuring that research relates to the needs and opportunities of resource-poor farmers; that academic excellence is based on socially relevant concerns; and that ex ante impact assessments are carried out with technography and diagnostic studies. The studies conclude that trying to foster agricultural development through technology alone, when the necessary institutional conditions are absent, will probably not succeed. A combination of issues must be assessed: "hardware" issues (technologies such as new varieties, better agronomic practices, or soil improvement measures), "software" issues (changed mindsets and goals, such as a shift in focus from yield improvement to farmer empowerment); and "orgware" issues (different organizational arrangements and institutions, such as better market outlets, different labor arrangements, and adding value to products). A few examples

- An increase in the producer price for cocoa in Ghana from 2001 to 2004 increased cocoa production by an astounding 80 percent.

- Setting up a task force resolved corrupt and extractive cheating with weighing scales by the Licence Buying Companies for cocoa in Ghana.

- New tenure arrangements broke up patrimonial networks impeding investments in soil fertility, such as tree planting, which is a covert claim to land ownership.

- In sorghum production for the brewery industry in northern Ghana, creating a dynamic relationship between the private sector, farmers, scientists, and nongovernmental organizations (NGOs) in contract farming under market-driven conditions can improve access to markets.

- Cotton in Benin can be produced more sustainably by stopping rent seeking by private organizations, which impedes the delivery of inputs needed for integrated pest management.

Oil palm in Benin production systems (CoS-SIS)41

Based on a formal diagnostic survey and subsequent focus group discussions (FGD) with farmers an improved variety of hybrid Napier sourced from the Agricultural university was provided to select farmers as part of a 3-year project aiming at enhancing the livelihoods of poor livestock keepers by improving availability of fodder. The original assumption was that the recipient farmers would demonstrate the improved fodder technology and share the planting material with other farmers. However, in practice an institutional innovation in the form of a fodder market emerged between resource farmers and other small farmers and the landless. Seller farmers, buyer farmers and the milk union anchored the scale-up of Napier because it addressed their interests and needs. The paper discusses the importance of coalitions of actors in generation and application of knowledge towards

enhancement of livelihoods and poverty reduction.[42]

Lessons from Napier Case

In the present context all three parties – buyer farmers, seller farmers and the milk union stand to gain from the Napier scale-up. The buyer farmers, who would otherwise have to buy more expensive concentrate feed and/or more paddy straw, benefit from the reduced cost of milk production and are able to take advantage of higher production and producer price particularly in summer months. For the seller farmers the income from Napier compares very well with the alternatives like cotton and mango. The milk union not only found a way out to address the demands from producers but the increased milk production is likely to improve capacity utilization of the dairy plant, making it a more viable enterprise. Small farmers who buy Napier are also happy about Union supplying slips of improved Napier variety to seller farmers as it improves their relation with them through the market arrangement. The actors have so far addressed their self-interests and specific agendas in making the Napier market a reality on the ground. Biggs and Smith (1998) argue that the emergence of a particular technology depends not only on its scientific merits but on the actions of what they term 'development coalitions'- loose groupings of actors who combine their resources to push for a particular path of technical change. The institutional innovation in the form of fodder market through lease arrangement between selling and buying farmers was not only the driving factor for scale-up of Napier it also ensured that the innovation remained pro-small farmer. In other words it influenced the 'Reach' of the technical innovation. 'Reach', defined by the evaluation unit of International development Research Centre (IDRC) refers to the 'the groups that are touched by the results of a program' (Earl et al, 2001).

Participatory technology development in support of artisanal palm oil production in Ghana43

The research started off with exploratory and scoping which showed that Ghana's industrial (good) quality crude palm oil (CPO) production have stagnated over the last 12 years, while domestic consumption continues to increase with a growth rate of 2.8%. Import for the commodity is estimated to increase to over 125,000 metric tons (MT) by 2025. There is also a growing West African market which demands close to 1 million MT a year. Artisanal oil palm processing is a source of income for many females in rural Ghana. Ghana thus has the potential to meet the growing market interest both domestically and internationally. However, it was established from a diagnostic study that the artisanal enterprise is faced with a myriad of multi-faceted constraints, particularly the production of poor quality palm oil of high free fatty acid levels which makes access to such remunerative markets difficult. The local knowledge of artisanal mill practitioners was first observed and learned through ethnographic methods to understand the details of processing practices, actors' interfaces and engagements in social networks. These social insights from the practitioners provided a sound basis or hypothesis for a joint experimentation activity. It was found the processing practice of storing fruits for several days lead to production of poor quality palm oil. A joint experimentation group planned and implemented processing activities for four different storage periods (3, 7, 14 and 21 days) to learn about the variation of fruit storage after harvesting on palm oil yield and quality. This was done alongside a researcher-managed experiment on the same issue and a profitability analysis to ascertain whether it is profitable for processors to improve the quality or continue with the former processing practice and produce poorer quality palm oil. A local stakeholder's platform was formed to help various stakeholders (scientists, extensionists, mill practitioners, farmers etc.) to put their perspectives, knowledge and skills together to address. The joint experimentation and discussion of its outcomes at the stakeholders' platform were useful in enhancing learning, leading to a reduction in fruit storage period as a processing practice and thus lowering free fatty acid level. In addition, higher-level stakeholders at both the district and national levels were engaged with as an innovation platform (Concerted Innovation Group), and linked up to support the local struggle of learning to produce good quality of palm oil.

It is concluded that different models of information sharing and interventions are necessary and complement each other to address different levels of constraints in the artisanal oil pam processing. The multi-scale stakeholder approach used in the research ensured the flow of knowledge at different levels, for instance between artisanal mill practitioners; within scientific or extension community; and also

between the practitioners, scientists and extension service. The artisanal oil palm processing enterprise is able to innovate if all relevant stakeholders (are willing to) learn to overcome constraints and create opportunities, and also change institutions which negatively affect the enterprise.

Joint experimentation on fish smoking in Niger

A team of scientists and extensionists in Prolinnova–Niger discovered a locally developed fishsmoking oven in the village of Boumba Kaina in Dosso Region. The community was aware of the oven's limitations and responsive to the team in setting up a joint experiment to improve it. Ideas of the community and the team were blended in designing a new oven. Four farmers (2 men and 2 women) compared the improved oven with the local one. The roles and responsibilities of the different stakeholders in the joint research were clearly worked out – the farmers took the lead; the Prolinnova team played a supportive role. The improved ovens proved far superior to the existing ones on many counts such as quality of smoked fish, wood-burning efficiency, duration of smoking etc. The fish smoked in the improved ovens fetched higher prices on the market and the demand increased. This led to further socio-economic developments in Boumba. Several families invested in making new ovens on their own. The fish-smokers set up a savings-and-credit scheme to finance construction of new ovens. Women and men requested literacy training so that they could monitor their own experiments. [44]

Controlling bacterial wilt

AgriService Ethiopia (ASE), coordinating NGO of Prolinnova–Ethiopia, discovered that farmers were actively seeking how to control bacterial wilt, a major problem in the staple food in southern Ethiopia: enset *(Enset ventricosum)* or "false banana". This had not been a major focus of formal research but, in Amaro District, farmer innovators Behailu, Somali and Dereso were experimenting with extracts from euphorbia, Aloe vera and wood ash, respectively. A District Research Coordination Forum with experts from Awassa Research Centre (ARC), the Office of Agriculture and ASE supported farmers in conducting trials to compare the effectiveness of these locally developed innovations. A plant pathologist from ARC gave advice in experimental design and data collection. The farmers applied the treatments and, guided by the scientist, inoculated the plants with bacteria. They observed how the disease spread. The farmers found the euphorbia extract to be most effective. ASE and development agents (DAs) organized field days and workshops for joint learning by other farmers and DAs. The experience not only validated local innovation but also increased the farmers' confidence to interact with formal researchers.[45]

Malawi, building public-private partnerships in the cotton sector

Cotton is a strategic crop in Malawi with a value chain that includes nearly 200,000 cotton growers, ginning, spinning, textile and garment manufacture and oil extraction industries with both domestic and export markets.

The cotton sector has faced a number of challenges among which are: low productivity, weak institutional structures, low investment in both production and value addition, and the lack of a cohesive national strategy to guide the sector This has given rise to conflicting interests between stakeholders to the detriment of all actors in the industry.

A number of initiatives based on stakeholder interactions culminated in the formation of a Cotton Development Trust (CDT) comprising all cotton value chain actors. Through the formation of four thematic groups concerned with improving research, extension and farmer productivity, marketing and pricing, policy and regulation, and financing concerns, CDT has achieved remarkable progress in a short time. This includes: acceptance and recognition of CDT by all stakeholders including Government, contributing to the review of the Cotton Act that will provide the regulatory framework for the cotton sector, initiation of a 5-year strategic plan to guide cotton development, support for establishing the National Cotton Farmers' Association of Malawi (COFAM) to represent all cotton farmers, advocacy for improvement of certified seed supplies and reduction in the use of recycled seed, establishment of cotton test and demonstration plots linked to research undertaken by Government's Makoka Research Station, establishment of a consultative platform for negotiation of seed cotton farm-gate prices and participation in a wider regional cotton development initiative including Malawi, Mozambique, Zambia and Zimbabwe.[46]

Farmer-driven research to improve food and nutrition security

Maize commodity chain in Nigeria

Positive indications of this were obtained in a recent effort in Southwest Nigeria where an innovation platform was set up around the maize commodity chain. In this innovation platform, scientists from the International Institute of Tropical Agriculture and the Bowen University in Nigeria worked with other stakeholders including Adom Feeds Ltd which is a livestock feed-mill located in Ibadan as an example of output markets, Adedigba enterprises located in Ago Are selling inputs, Tractor Hiring Association of Ago Are, Union Bank Nigeria Ltd. (providing credit) and the State Extension Services. Farmers numbering about five thousand (5000) were part of this platform as producers. The research plan was centered on the development of optimal management practices for a new variety of maize which has demonstrated reasonable resistance to maize streak and downy mildew diseases of maize. Three years after the platform had been established the adoption rate for the new variety of maize and the management practices were almost hundred percent resulting in doubling in yield per hectare and income to farmers. Similarly, other stakeholders including the Bank, Input dealers, Tractor Hiring Agents, also recorded significant increases in sales and income while the end user recorded savings from the lubricated supply chain.[47]

Kenya's sweet potatoes48

The research and development of an orange-fleshed sweet potato, high in ß-carotene, invaluable for improving household nutrition and food security especially in times of hunger or drought, and for pre-natal care and households affected by Human Immunodeficiency Virus/ Acquired Immunodeficiency Syndrome (HIV/ AIDS). New varieties were developed as a result of a ten-year research programme. Government extension services and a number of NGOs have subsequently participated in programmes providing training, propagation and distribution of vines, processing and the linking of producers to markets. These programmes covered many parts of Kenya but in particular Coast, Eastern, Rift Valley, Nyanza and Western Provinces. Production of the OFSP or other commodities grown by smallholders who are participating in group initiatives can be successful if there are contract markets to provide the stability for increasing production. It also requires support for breeding, production and utilisation. Greater involvement of nutrition research activities may have contributed even more to the ongoing success.

- The **Participatory Market Chain Approach (PMCA)** differs from other market chain approaches because of its focus on stimulating innovation and long-term partnerships among farmers, market agents, and service providers. It pays particular attention to engaging private sector actors, who are critical in identifying and making use of new market opportunities.
  The PMCA was developed by the Papa Andina Initiative and its partners, the Foundation for Promotion and Research on Andean Crops (PROINPA) in Bolivia, and the project for Technological Innovation and Competitiveness (INCOPA) in Peru, to improve the competitiveness of small potato producers in the Andes. Innovation in the food and agriculture sector is frequently short-circuited by a lack of trust and communication between actors in the market chain.
  To overcome these problems and stimulate innovation, the Participatory Market Chain Approach (PMCA) brings together small farmers, market agents, and service providers for an intense process of facilitated interaction. The PMCA uses a flexible three-stage participatory process to improve communication, build trust, and facilitate collaboration among participants so that they can jointly identify, analyze, and exploit new market opportunities. The PMCA focuses on innovation in products, technologies, and ways of working together. By carefully selecting market chains and partners, and building in social responsibility, the PMCA can lead to favourable outcomes and impacts for poor farmers, typically the weakest link in the chain. The PMCA requires facilitation and technical support from professionals with good social skills, research experience, and marketing knowledge, based in a neutral research and development organization. To ensure that impacts are sustained, the PMCA is best used as part of a broader programme of market chain development.
  The PMCA was first applied in 2002 in Peru to the potato sector, triggering commercial, technological, and institutional innovations to native potatoes grown by small farmers in

the high Andes. This led to a marketing concept for selected native potatoes: attractive bags of potatoes sold in supermarkets as the gourmet product, 'T'ikapapa'. This product, launched in Lima's leading supermarket chain won prestigious national and international awards. In 2003, Papa Andina shared Peru's in Bolivia and farm communities developed commercial partnerships with potato processors and supermarkets, making native potato products available to consumers in Bolivia's principal cities.
In 2005, local groups promoting market chain development in Uganda visited PMCA projects in Bolivia and Peru and subsequently applied PMCA in commodity chains for potato, sweet potato, tomato, and hot pepper. In each case, PMCA triggered product development and improved relationships among market-chain actors and R&D professionals. This has led to improved collaboration in other activities as well. More recently, the PMCA has been used in potato, coffee, and dairy market chains in Bolivia, Peru and Colombia, and for potatoes in Indonesia. period of follow-up is required to generate successful innovations with tangible benefits. Farmers may require complementary capacity building (for example in organization and enterprise development) if they are to make full use of the opportunities created by the PMCA. As innovation processes grow to involve a broader group of actors, it may be difficult to ensure that benefits flow mainly to the poor. Whilst many organizations and actors have benefited from using the PMCA, institutionalizing the approach remains a challenge. For this reason, we are now developing a programme for PMCA capacity development. [49]

Linking market and other network: Ethiopian coffee sector

An innovation system framework and social network analysis tool were used to assess ways of leveraging change to benefit small-holders in the Ethiopian coffee sector.[50] In this case, networks formed around dense concentrations of public sector service providers, Sometimes NGOs complemented the public sector by increasing the size of the network and connecting smallholders (directly or indirectly) with other innovation actors. The market agents remained peripheral, however. An innovation system relying on interaction between farmers, the public sector, and NGOs cannot respond well to market signals if market actors are not present or remain peripheral. In particular, smallholders' ability to innovate in response to changes in the market—to change on-farm practices and strategies—is potentially constrained. This case illustrates the power of networks that are closely linked to smallholders' innovation processes. Such networks affect: (1) the roles and responsibilities of diverse actors; (2) their relationships and interactions; (3) policy and market environments that influence innovation; (4) the complex dynamics of innovation; and (5) potential areas for strategic policy interventions.

Ethiopia's Sidama coffee51

The production of Sidama coffee, a premium coffee, is grown primarily by smallholders. When coffee prices collapsed during the 1990s, farmers were faced with decreasing yields, poor quality and low prices. The establishment of the Sidama Coffee Farmers Cooperative Union (SCFCU) in 2001 and subsequently the Ethiopian Government's policy change to allow direct exports from recognized sources like SCFCU played a major role in resuscitating the Sidama coffee industry. SCFCU's involvement in vertical integration of production, processing and marketing has resulted in yield, quality and price increases for producers. Additionally, SCFCU service to members that includes training, advice, inputs, savings and credit ensures yield and quality maintenance. Simultaneously, Government has provided important support for research in improved varieties and management practices. The Ethiopian Commodity Exchange (ECX, 2011) provides a marketplace that compliments the role of SCFCU. This provides a forum where buyers and sellers come together to trade and be assured of quality, delivery and payment. It deals in six commodities including coffee, sesame, haricot beans, teff, wheat and maize. Any Sidama export coffee that is not marketed by SCFCU can be auctioned through ECX.

Vertical integration along the value chain has ensured that producers obtain a fair share of the final value. SCFCU involvement in production, processing and marketing has ensured good quality at reasonable prices with the whole sector being owned and managed by farmers and their employees.[52]

There are now over 87,000 individual SCFCU members producing over 35,000 tonnes of Sidama coffee from 70,000 hectares. SCFCU includes 45 primary producer societies each of which typically has some 2000 coffee producers (SCFU, 2011). Two of SCFCU's primary societies have been certified for organic Sidama coffee production and SCFCU has become a registered member of the Specialty Coffee Association of America. SCFCU's vertical integration from production to export of coffee beans is ensuring a quality product at fair prices, with the exploitative role of private traders being minimised. At the same time ECX complements the marketing functions of SCFCU. By selling directly to the customers SCFU ensures that the value paid to the producer has increased substantially.

Quncho: the first popular tef variety in Ethiopia53

Tef, Eragrostis tef (Zucc.) Trotter is the main Ethiopian cereal annually grown on 2.5 million ha, and accounts for 30 per cent of total acreage and 19 per cent of gross cereal production (CSA, 2008). The crop has both its origin and diversity in Ethiopia, and plays a vital role in the country's overall food security. The straw is an important cattle feed source, and the high market prices of both its grains and the straw make it a highly valued cash crop for tef-growing smallholder farmers. Tef is a highly versatile crop with respect to adaptation to different agro-ecologies, with reasonable resilience to both drought and waterlogging (Assefa et al., 2010). The major constraints in tef husbandry are low productivity (national average about 1t ha21) and susceptibility to lodging. Scientific research on tef began in the late 1950s, and over the years a number of improved varieties (about 30 at the national level) and management practices have been developed. However, the research outputs were so little adopted by the farmers and have brought few discernible impacts. Being of local importance, no international funding or research attention was given to it until recently. For tef, outstanding support has been provided by the McKnight Foundation's Collaborative Crop Research Program (MF-CCRP) to the Ethiopian Institute of Agricultural Research since 1996.

The institutional innovations that greatly contributed towards the success of the new tef variety, Quncho, include the participatory variety selection (PVS) and participatory plant breeding (PPB): These activities enabled the identification of important farmer- and consumer-preferred traits in improved tef varieties. This, in turn, allowed the designing of targeted crossing, which eventually resulted in the development of the tef variety Quncho that fits the most important farmers' selection criteria driven by market, seed colour and yield (Belay et al., 2006, 2008). This has prompted breeders to deliberately select for seed colour quality in segregating populations for the first time.

Latin American and Caribbean Consortium to Support Cassava Research and Development (CLAYUCA)54

CLAYUCA transcended the traditional country based model of cassava research to develop a regional research and development network that attracted nontraditional partners and funding. All members participate in planning, financing, and implementing prioritized activities for cassava research and development while sharing costs, risks, and benefits.

The innovative aspect of CLAYUCA is its role as a regional facilitator of public-private alliances for cassava research and development, using a value chain approach and emphasizing competitiveness. Different actors in a member country's cassava subsector identify where cassava's overall competitiveness can be improved along the value chain (production, processing, or utilization). They identify organizational and technical constraints and formulate and implement technological interventions. The new emphasis on competitiveness, a prerequisite for private sector involvement in cassava-based industries, has motivated farmers, especially small-scale farmers, to adopt improved production technologies such as better varieties and improved crop and soil management practices. Increased competitiveness on the supply side is complemented by private investments and contributions to processing capacity and management. The network's regional and international character offers particular advantages for countries where cassava research has been limited by small national budgets and little external interaction.

Successes in innovation in the agriculture and value chains sector

Joint learning was central to the EU funded multi-partner project Joint Learning about **Innovation Systems in African Agriculture** JOLISAA. The project gave the

researchers in Africa and Europe a chance to learn about existing innovation cases on the ground and to learn from the people involved in these cases as well as from the project partners in other countries. The learning was in three phases: developing methodology, taking stock of innovation cases, and jointly assessing selected cases. In these phases, partners and stakeholders met physically or virtually for several learning events. At the outset, CIRAD and WUR helped the team to develop a common understanding of key concepts to be used when identifying and analyzing the cases, such as innovation systems, type of innovation, trigger of innovation, scale and phase of innovation, innovation brokers and local knowledge. Enriched by insights from the JOLISAA International Learning and Advisory Group (JILAC), the initial internal paper and the subsequent full---fledged literature review on these concepts reflected current debates on agricultural innovation systems and the role of local knowledge.

JOLISAA internally refers to this situation as “innovation bundles”. New dimensions may result from new stakeholders coming on-board, or simply from stakeholders starting to actually change their practices and in so doing, transforming or taking advantage in different ways of the environment in which they operate.

- The evolution of soybean growing and processing in Benin offers a striking example of such a bundle. Soybean was first introduced in the 1970s as an infant protein-rich food while farmers were shown how to grow it and use it in traditional cooking recipes. After a long latency period, soybean growing increased in central Benin as the cotton value-chain underwent a multi-pronged prolonged crisis. This prompted oil processing factories to develop contractual arrangements with farmers and their organizations to replace cotton seed with soybean. In recent years, as an alternative to the powerful industrial soybean oil value chain, farmers’ organizations have supported producer-led soybean food chains based on small scale soybean cheese and oil processing equipment, coupled with the development of poultry husbandry using the soybean bran.[55]

- In Kenya for instance, the initial introduction of the Prosopis sp. as a way to restore degraded lands was considered a success until it was perceived by farmers as an obnoxious invasive species which had to be eradicated. Faced with this challenge, a new innovation iteration took place which eventually yielded viable strategies and options for managing and using Prosopis by using its pods for forage, by burning it to produce high-quality charcoal, and by producing quality honey from Prosopis stands. The seemingly frequent occurrence of such a changing innovation landscape over time questions the ability and relevance of the many existing assessments based on shorter time-lines to reflect, not to mention predict, the actual fate of what should perhaps be called initial innovations, to differentiate them from final innovations.[56]

6. Lessons learned and the way forward

Some of the projects such as Convergence of Sciences (CoS 1)[57] have analysed participatory innovation processes to find more efficient and effective modes of agricultural research and technology development. The main conclusions were that it is not difficult to find technical or biological solutions to farmers' problems, however, a deficient interface of institutions and technology constrains adoption and/or adaptation of these technologies, thereby limiting the impact of research on especially smallholder farmers. What is needed are innovations that combine technical, institutional and organisational aspects that have been co-developed in a coherent manner to address constraints holistically. This will typically involve: (i) combining natural and social sciences, (ii) clear policy support, and (iii) engaging with all relevant institutions. To successfully develop such innovations, it is necessary to operate above conducting research at farm level and build networks amongst all relevant institutions and stakeholders.

There is a need to move from an exclusive focus on farmers, farms and technologies to broader innovation systems – markets, institutions, politics and policies really matter, too. This requires new skills, new partnerships and new institutional configurations – largely absent in most agricultural research and development systems. Agricultural education systems and most curricula do not address the challenges of today. Methodologies are needed that recast the way we do research and monitor and appraise he results – and the researchers themselves. There is a need to overhaul incentive and reward systems to put farmers first and promote "participatory innovation systems". A "politics of demand" needs to be put at the centre of a new set of accountability mechanisms for research and development. This requires building capacity and voice for farmer organisations so they can exert pressure and demand for appropriate research and other services. But it also means having more responsive service delivery organisations.

It needs to be highlighted that few efforts have been made to include women in ARD discussions and co-implementing research, even though they are involved in all aspects of food production—cultivation, selection and conservation of seeds—and have a deeper understanding of culinary and nutritional quality than men. There has also been insufficient attention to including youth, who are the future of farming.

Land users, including smallholder farmers, men and women, are innovators in their own right playing an important role in enhancing food security and income generation. They possess invaluable knowledge about their own environment, and identify, develop and finetune innovations suited to their specific needs. It is increasingly realised that much can be gained if agricultural innovation programmes and actors link up with, empower and support local innovation processes using a farmer-led participatory innovation approach. Existing ways to fund agricultural innovation do not encourage collaboration between local innovators and ARD agencies.[58]

To have a positive impact on smallholders, formal research needs to involve farmers at all stages – in determining needs, identifying problems and opportunities, designing and testing new possibilities, sharing results, and assessing the way the research is done and the results shared. Extension services, or rural advisory services, are vital knowledge-sharing institutions, crucial to achieving the social, economic and environmental elements of sustainable development. Extension services can help improve livelihoods by providing vital information, technologies and knowledge to farmers but also by eliciting farmers' own knowledge and creativity and facilitating the link between different sources of knowledge and information. It can also provide access via mobile phones to market data such as weather projections and livestock prices, offers knowledge centres with information on new crop varieties, and index-based insurance through private sector engagement with local communities.

Institutions of higher education need to incorporate methods of experiential and participatory learning in order to create linkages between students and farmer-researchers. This would prepare the students as future ARD professionals who are open to engage with farmers in joint research – and also to become famer-researchers themselves. Staff of these institutions will need support to transform curricula and to find creative ways to involve innovative farmers and groups in learning cycles.[59]

Similarly, designing **new funding mechanisms** in attempts to empower clients and direct ARD towards their

innovation needs is also a major focus. This requires a revaluation of funding at all levels — from donors and agricultural research and extension organisations to farmers' and non-governmental organisations.

One of the key issues for **science and technology policy** is to contribute to establishing an enabling environment for innovation. Ways to address this need include: establishing institutions and mechanisms to implement and enforce an enabling environment; promoting stakeholder engagement and collaboration through foresight activities, innovation platforms, adequate incentives for actors, and the development of interaction rules (related to intellectual property rights, research funding, agent roles, and so on); and strengthening knowledge management capacities and collaboration arrangements that will lead to a better use of available information, knowledge, and technologies at the national, regional, and global level, both in the public and private sector.

There is no longer a single source of information and technology, and bringing about innovation and change requires a collective intelligence involving collaboration between different knowledge sources.

Interventions to encourage innovation depend on the initial context and how this changes over time. They should not focus first on developing research capacity, but should be developed from the start in a way that encourages interactions between public, private and civil society organisations.

GLOSSARY

Advisory services

Advisory service(s) is commonly used as an alternate term for extension services. These systems involve a broad spectrum of market and non-market entities, and agents are expected to provide useful technical information about new technologies that can improve the income and welfare of farmers and other rural people.

Agricultural extension

Agricultural extension can be defined as the entire set of organizations that support people engaged in agricultural production and facilitate their efforts to solve problems; link to markets and other players in the agricultural value chain; and obtain information, skills, and technologies to improve their livelihoods.

AIS (Agricultural Innovation Systems)

Tthese are defined as '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 the way different agents interact, share, access, exchange and use knowledge'.

AKIS (Agricultural Knowledge and Information System)

The original formulation described "a set of agricultural organizations and/or persons, and the links and interactions between them, engaged in the generation, transformation, transmission, storage, retrieval, integration, diffusion and utilization of knowledge and information, with the purpose of working synergistically to support decision making, problem solving and innovation in agriculture". This concept develops the notion of AKS, emphasizing the process of knowledge generation and includes actors outside the research, education and advice sectors. More recently the AKIS concept has evolved as it has acquired a second meaning (innovation) and opening up AKIS to more public tasks and to the support of innovation.

AKS (Agricultural Knowledge System)

A collection of actors, such as researchers, advisors and educators, working primarily in agricultural knowledge institutes. The emphasis is on these actors and the role of formal knowledge production in national agricultural research systems (NARS). This knowledge is then transferred to the agricultural sector through agricultural extension services and education.

Capacity development

The process whereby individuals, organizations and society as a whole unleash, strengthen, create, adapt and maintain capacity over time.

Collective action

Voluntary action to collaborate in pursuit of a common goal taken by a group.

Commodity-Based Advisory Services

Commodity-based advisory services are similar to value-chain extension systems, in which an economically important crop or product, generally for export (e.g., cotton, coffee, other high-value crops or products), requires that producers use specified genetic materials or varieties and follow strict quality-control standards in producing and harvesting the crop or product.

Commodity-Based Innovation Systems

A commodity-based innovation system incorporates the various actors, their actions and interactions, as well as the enabling environment, facilitating institutions, and services that condition the various forms of innovation along the value chain of that commodity. This emphasizes the notion that innovation can occur anywhere along the value chain, not necessarily at the farm level, thus broadening the research agenda to incorporate both biophysical and socioeconomic research within the research for development portfolio.

Decentralized Extension

The concept of decentralized extension is based on three major factors: (1) transferring specific decision-making functions to local levels, starting with simple managerial functions, then setting priorities and allocating funds and providing other administrative functions, including accountability and financing/co-financing; (2) encouraging public participation, reflecting the degree of authority that is formally transferred to rural people, starting in an advisory capacity for program planning and implementation, and eventually assuming control over selected financial planning and accountability functions; and (3) expanding local involvement in organizing and

delivering extension services, which reflects the level of control that local governments and/or other institutions, including private firms and NGOs, have for implementing specific extension activities. For more information on decentralization, see Module 3 of the Agricultural Investment Sourcebook (World Bank 2006a).

Diffusion of Innovation

Diffusion of innovation is the process by which new ideas and technologies spread through different farming systems, countries, and cultures. Everett Roger's innovation theory (2003) states that innovation diffusion is a process that occurs over time through five stages: knowledge, persuasion, decision, implementation, and confirmation. Accordingly, the innovation–decision process is the process through which an individual or other decision-making unit passes through the stages of (1) having awareness and knowledge of an innovation, (2) forming an attitude toward the innovation, (3) making a decision to adopt (or reject) the innovation, (4) implementing the new innovation, and (5) confirming the decision

Empowerment

Process of enhancing an individual's or group's capacity to make purposive choices and to transform these choices into desired outcomes.

Enabling environment

Policies and practices that stimulate and support effective and efficient functioning of public and private organizations (for-profit and non-for-profit ones) and individuals.

Farmer Field School (FFS)

Farmer Field Schools consist of groups of farmers with a common interest who get together on a regular basis to study the "how and why" of a particular topic. They learn from field observation and experimentation (learning by doing), such as integrated pest management (IPM). Originally, the FFS approach was developed by FAO to transfer IPM technologies to farmers in Indonesia. The FFS approach may be applicable wherever a subject is open to a process of active learning in the field, either using demonstration techniques or real experimentation to uncover new local knowledge. The FFS curriculum follows the natural cycle of its subject, in parallel with what is happening in the FFS member's field.

Human capital

The skills, knowledge, ability to labour and good health that together enable people to pursue different livelihood strategies and achieve their livelihood objectives (Department For International Development – DFID, 1999). It covers people's innate abilities and talents plus their knowledge, skills, and experience that make them economically productive. Human capital can be increased by investing in health care, education, and job training.

Innovation

An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations. Innovation activities are all scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. These activities themselves need not to be novel, but are necessary for the implementation of innovations. An innovative firm (farm) is one that has implemented an innovation during the period under review. Four types of innovation are distinguished: product innovations, process innovations, marketing innovations and organizational.

Innovation brokers

Teams of specialists that combine a strong background in science with knowledge of business and commercialization and/or the creation of innovation networks. Innovation brokers are also known as change agents or technology brokers.

Innovation capabilities

The skills to build and integrate internal and external resources to address problems or take advantage of opportunities.

Innovation network.

A diverse group of actors that voluntarily contribute knowledge and other resources (such as money, equipment, and land) to jointly develop or improve a social or economic process or product. These networks are also known as innovation platforms.

Innovation system

An innovation system can be defined at the national or sectoral level, or from the perspective of a commodity or intervention. An innovation system has three elements: (1) the organization and individuals

involved in generating, diffusing, adapting, and using new knowledge; (2) the interactive learning that occurs when organizations engage in these processes and the way this leads to new products and processes (innovation); and (3) the institutions—rules, norms, and conventions, both formal and informal—that govern how these interactions and processes take place (Horton 1990; North 1995). Innovations systems as a concept is the study of how societies generate, exchange, and use knowledge.

Institutional arrangements:

Inter-agent coordination between producer organizations (POs) and other social and economic actors, such as stakeholder committees, networks, forums, platforms, public-private partnerships, and contracts.

Institutions

"Rules by which agents interact and the organizations that implement rules and codes of conduct to achieve desired outcomes".

Interprofessional association:

A private body, recognized by the state, which groups together upstream and downstream partners of the same commodity along a value chain. It represents the interests of the sector as a whole. Such bodies elaborate alternative contractual policies for members to increase the competitiveness of the sector and defend their interests. An important feature of interprofessional association is that the membership is made up of the diverse associations representing the professions within a value chain and not individuals or companies.

Linking relations

Connections with actors in politically or economically influential positions (Woolcock and Sweetser, 2002). Linking relations include connections between small producers and a wide range of private and public actors, such as contract farming models, private-public partnerships, interprofessional or value-chain organizations, but also through network and forums.

Learning

Knowledge is an interactive (social) process that takes place within cognitive frames (paradigms, cognitive rules and regimes) in response to problems, opportunities and challenges. Individual and/or collective learning occurs in various ways: learning by doing, social learning, transdisciplinary learning, transformative learning, etc. and is a necessary precondition for

LINSA (Learning and Innovation Networks for Sustainable Agriculture)

This concept is linked to the network approach of AKIS. It describes thematically-focused learning networks that are made up of different actors, within and outside the formal, institutionalized, AKS. Members can include farmers, extension workers, researchers, government representatives and other stakeholders (Rudman, 2010). LINSAS are similar to 'coalitions' (Biggs and Smith, 1998)), innovation configurations (Engel, 1995) and Public Private Partnerships (Hall, 2006). The emphasis is on the process of generating learning and innovation through interactions between the involved actors.

The difference between AKS and LINSAs is connected to how knowledge is conceptualized: AKS sees knowledge as a "stock to be transferred", whereas LINSA emphasizes the processes needed to make knowledge useful and applicable to other actors. In other words LINSA are one of the ways to strengthen the I of Innovation in the AKS. The LINSA concept helps to illuminate and extend some forms of AKIS, which may be otherwise hidden or marginalized.

Market-Driven Extension (MDE)

Market-driven extension is a relatively new concept in which the focus of a technology transfer-driven agricultural extension system shifts 180 degrees—or from "research" to the "market," especially for high-value crops, livestock, fisheries, or other products. This change in focus is consistent with the concept of a market-driven agricultural innovation system (AIS), because market opportunities and access depend in part on the location of each farm (or groups of farmers), farm size (to produce specific products), and many other factors, such as agro-ecological conditions, transportation infrastructure, available labor, and, possibly, access to other production resources, such as irrigation, greenhouses, etc. Therefore, the decision by groups of farmers to supply specific markets with different high-value crops or products will depend in large part on the relative size of accessible markets for particular products and the strategic advantage of producer groups to supply these markets with high-value crops or products.

Negotiating Power or Bargaining power

Relative ability of an actor, a person or a group, in a situation to exert influence over other actors. It is the strength that an actor has by exercising and imposing its point of view over others.

Network

System of interlaced webs of relationships in which control is loose, power diffused and centres of decision plural.

Organizational capacity development

Process to enhance the capacity of organizations to perform their goals and better fulfil their missions.

Organizations

Clusters of individuals working together toward a shared goal. “Groups of individuals bound by some common purpose to achieve objectives” .

Participatory Extension

The participatory extension paradigm is essentially a combination of technology transfer, advisory services, and human resources development and involves two key elements. The first element addresses how extension systems are organized and emphasizes the fact that all types of farmers, especially small-scale and women farmers, must play an important role in setting extension priorities and shaping extension programs. By so doing, farmers will take more “ownership” over these ongoing extension programs and operations. The second key element of the participatory extension approach generally encompasses more participatory extension methods, such as experiential learning and farmer-to-farmer exchanges. It emphasizes that knowledge is gained through interactive processes that include extension field staff, private-sector firms, NGOs, and/or innovative and progressive farmers within local or nearby communities. Participants are expected to make their own decisions, especially about how they will intensify and/or diversify their farming systems.

Participatory or inclusive innovations

Innovations developed through mechanisms that give all stakeholders, especially end users, a say during their development. Participatory innovations in agriculture involve farmers in a project’s design, development and dissemination stages, in the hope that their involvement will result in innovations that are targeted at farmers’ real needs and are widely adopted.

Participatory Rural Appraisal (PRA)

Participatory rural appraisal is a label given to a family of participatory approaches and methods that emphasize local knowledge and enable local people to make their own appraisal, analysis, and plans. The key tenets of a PRA are participation, teamwork, flexibility, and triangulation to ensure that information is valid and reliable.

Peer to Peer advice

An innovative practice in which people with similar positions in comparable organizations and who speak the same language exchange knowledge on how to address problems and constraints and thereby strengthen rural organizational skills.

Public-Private Partnership

Cooperative venture between public sector (government and other public agencies) and private business or not-for-profit civil society organizations. The agreement builds on the expertise of each partner to meet clear goals and share resources, risks and rewards. When private actors share the public interest in economic development, public agencies may be able to engage in certain development activities jointly with them.

Social capital

Collective resource of a group in terms of networks and social trust which facilitate its collective action for mutual benefit

System

A system is a collection of related elements that must function in concert to achieve a desired result. It consists of interlinked subsystems, of which it is more than the sum; the central feature is its integrity and synergy. A system contains one or more feedback loops that are central to the system’s behavior and permit the system to function in a self-managed, self-sustained way. Two key conclusions emerge from systems thinking: (1) the interrelated parts drive the system, and (2) the feedback loops are circular rather than linear.

ACRONYMS

AFAAS	African Forum for Agricultural Advisory Services
AFAAS	The African Forum for Agricultural Advisory Services
AfDB	African Development Bank
AET	Agricultural education and training
AIS	Agricultural innovation system
AKIS	Agricultural Knowledge and Innovation Systems
ARD	Agricultural Research for Development
ARI	Agriculture Research Institute
ASARECA	Association for Strengthening Agricultural Research in East and Central Africa
ASTI-indicator	Agricultural science and technology indicator
ASTI-system	Agricultural science, technology and innovation system
ATPSN	African Technology Policy Studies Network
AWARD	African Women in Agricultural Research and Development
BSF	Biotechnology Stakeholders Forum
BTC	Belgium Development Agency
CAADP	Comprehensive Africa Agricultural Development Programme
CABI	CAB International
CAP	Common Agricultural Policy
CAPAD	Confederation of Agricultural Producer Associations for Development 47
CBO	Community-Based Organisation
CBR	Community-based research
CCARDESA	Centre for Coordination of Agricultural Research and Development for Southern Africa
CD & IC	Capacity Development & Institutional Change
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture)

CILLS	Interstate Committee for Drought Control in the Sahel
CIMMYT	International Maize and Wheat Improvement Center
CIP	Centro Internacional de la Papa (International Potato Center)
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CIS	Communication and Innovation Studies
CORAF	Conference of the Agricultural Research Leaders in West and Central Africa
COS-SIS	Convergence of Sciences – Strengthening Agricultural Innovation Systems
CSM	Civil Society Mechanism
CSO	Civil Society Organisation
CTA	Technical Centre for Agricultural and Rural Cooperation
DFID	Department for International Development
DGIS	Netherlands Ministry of Foreign Affairs
EAFF	Eastern Africa Farmers Federation
EC	European Commission
ECAPAPA	Eastern and Central Africa Programme for Agricultural Policy Analysis
ESAFF	Eastern and Southern Africa small-scale Farmers Forum
FANRPAN	Food Agriculture Natural Resources Policy Analysis Network
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
FFS	Farmer Field School
FO	Farmer Organisation
FPR	Farmer participatory research (FPR)
FSR	Farming Systems Research
GCARD	Global Conference on Agricultural Research and Development

GFAR	Global Forum for Agricultural Research
GFRAS	Global Forum for Rural Advisory Services
GMOs	Genetically Modified Organisms
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
IAC	International Agricultural Centre
IAR	Institute of Agricultural Research
IAR4D	Integrated agriculture research for development
IBAR	Inter-African Bureau for Animal Resources
ICRA	International Centre for development oriented Research in Agriculture
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and communication technologies
IDRC	International Development Research Centre
IDS	Institute for Development Studies
IFAD	International Fund for Agriculture Development
IFAP	International Federation of Agricultural Producers
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IIED	International Institute for Environment and Development
IIRR	International Institute of Rural Reconstruction
IITA	International Institute of Tropical Agriculture
ILAC	Institutional Learning and Change Initiative (CGIAR)
ILEIA	Centre Centre for learning on sustainable agriculture
ILRI	International Livestock Research Institute
INSARD	Including Smallholders in Agricultural Research for Development

IP(R)	Intellectual Property (Rights)
IPs	Innovation platforms
KARI	Kenya Agricultural Research Institute
KIOF	Kenya Institute of Organic Farming
KIT	Royal Tropical Institute (The Netherlands)
LEISA	Magazine on Low External Input and Sustainable Agriculture
LINK	Learning Innovation and Knowledge
MDTF	Multi Donor Trust Fund
NARES	National Agricultural Research and Extension Systems
NARI	National Agricultural Research Institute
NARS	National Agricultural Research System
NEPAD	New Partnership for Africa's Development
NGO	Non-Governmental Organisation
NIS	National Innovation System
OECD	Organisation for Economic Cooperation and Development
PAEPARD	Platform for African–European Partnership in ARDt
PCFS	People's Coalition for Food Sovereignty
PELUM	Participatory Ecological Land Use Management
PLAR	Participatory Learning and Action Research
PRA	Participatory Rapid Appraisal
PRGA	Participatory Research and Gender Analysis
PROLINNOVA	Promoting Local Innovation in ecologically oriented agriculture and NRM
PTD	Participatory Technology Development
RAAKS	Rapid Appraisal of Agricultural Knowledge Systems
RD&D	Research, Development, and Deployment
REPAOC	Réseau des Plates-formes nationales d'ONG d'Afrique de l'Ouest & Centre
RIU	Research-Into-Use

RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
S&T	Science and Technology
SCAR	European Union's Standing Committee on Agricultural Research
SLA	Sustainable Livelihoods Approach
SPAAR	Special Program for African Agricultural Research
SRO	Sub-regional Organisation
SSA	Sub-Saharan Africa
SSA NGOC	Sub-Saharan Africa Non-Governmental Organization Consortium
SSASI	Sub-Saharan Africa Seed Initiative
S&T	Science & Technology
TRIP	Trade-Related Intellectual Property Rights
TRIPS	Agreement on Trade-Related Aspects of Intellectual Property Rights
TVET	Technical–Vocational Education and Training
UN	United Nations
UNU-INTECH	United Nations University-Institute for New Technologies
UNU-MERIT	United Nations University – Maastricht
WB	World Bank
WECARD	West and Central African Council for Agricultural Research and Development
WFO	World Farmers Organization
WIPO	World Intellectual Property Organization
WUR	Wageningen University and Research Center

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AFAAS (The African Forum for Agricultural Advisory Services)
www.afas-africa.org

AGRINATURA (The European Alliance on agricultural knowledge for development)

AGRITERRA
http://www.agriterra.org/

CATIE
http://www.catie.ac.cr/index.php/en/

CCAFS

CIAT International Center for Tropical Agriculture,
http://ciat.cgiar.org/

CIRAD (Centre de coopération internationale en recherche agronomique pour le développement)
http://www.cirad.fr/

CGIAR System
http://www.cgiar.org

Convergence of Sciences
http://www.cos-sis.org/open/ShowPage.aspx?PageId=57

CTA- The Technical Centre for Agricultural and Rural Cooperation
http://knowledge.cta.int - http://knowledge.cta.int/Dossiers/S-T-Policy/Innovation-systems

http://www.cta.int/
http://Spore.cta.int
http://brusselsbriefings.net
http://agritrade.cta.int
http://ictupdate.cta.int/

EIARD (The European Initiative for Agricultural Research for Development)
http://www.eiard.org/

EFARD (European Forum on Agricultural Research for Development)
http://www.efard.eu/

ERA-ARD (The Agricultural Research for Development dimension of the European Research Area)

ETC Foundation
http://www.etc-international.org/

European Commission DG Research
http://ec.europa.eu/research/index.cfm?pg=home&lg=en

Farmer First
http://www.farmer-first.org/

FAO- Food and Agriculture Organization of the United Nations
http://www.fao.org

Future Agricultures
http://www.future-agricultures.org/

GFRAS (Global Forum for Rural Advisory Services)
http://www.g-fras.org/

ICRAF (World Agroforestry Center)
http://www.worldagroforestrycentre.org/

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)
http://www.icrisat.org/

IDS (Institute of Development Studies)
http://www.ids.ac.uk

IFPRI (The International Food Policy Research Institute)
http://www.ifpri.org

IIED (International Institute for Environment and Development)
http://www.iied.org

ILAC (Institutional Learning and Change Initiative)
http://www.cgiar-ilac.org

ILRI (International Livestock Research Institute)
http://www.ilri.org/

IRRI (International Rice Research Institute)
http://irri.org

JOLISAA (Joint learning in and about Innovation Systems in African Agriculture)
www.jolisaa.net

KIT (The Royal Tropical Institute- The Netherlands)
http://www.kit.nl/kit/Royal-Tropical-Institute-

KM4Dev (Knowledge Management for Development)
http://www.km4dev.org/

LINK (Learning INnovation Knowledge)
www.innovationsystems.org

UNU-MERIT
http://www.merit.unu.edu/

ODI (Overseas Development Institute)
http://www.odi.org.uk/Rapid/Index.html

KS-CGIAR (Knowledge Sharing in the CGIAR)
http://www.ks-cgiar.org/

LINK (Learning INnovation, Knowledge)
http://www.innovationstudies.org/

Impact Alliance
www.impactalliance.org

Farmer-driven research to improve food and nutrition security

IFDC (The International Fertilizer Development Center)
http://www.ifdc.org/

Prolinnova, PROmoting Local INNOVAtion in ecologically oriented agriculture and NRM
http://prolinnova.net/

Scidev (Science and Development Network)
http://www.scidev.net/

FAO (Sustainable Development Department)
http://www.fao.org/sd/ppdirect/ppre0053.htm

Wageningen University
http://www.wageningenur.nl/en.htm

World Bank – Agricultural innovation systems
http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTARD/0,,contentMDK:23048376~pagePK:210058~piPK:210062~theSitePK:336682,00.html

WorldFish
www.worldfishcenter.org

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3 Agricultural Innovation Systems: An Investment Sourcebook. 2012 The World Bank

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