PART 5

Rationalizing and Aligning Institutional Structures
INTEGRATING AGRICULTURAL RESEARCH INTO AN AFRICAN INNOVATION SYSTEM

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In the 1970s and 1980s, national agricultural research institutes (NARIs) were created by consolidating disparate agricultural research units across various ministries into autonomous parastatals, which in many ways had the unintended side effect of isolating these new entities. Clear institutional boundaries reinforced the disarticulation between research and extension, and served to limit the interaction of NARI-based scientists with farmers (although this was partly addressed by farming-system research programs of the 1980s). All this occurred before the market liberalization of the 1990s, which left little scope for interaction with the private sector. This lack of organizational connectivity has continued to the present, even as the private sector has expanded, extension has moved to more pluralistic systems with greater connectivity, and farmers have significantly enhanced communications options through cellular phones. NARIs have tended to interact primarily with other agricultural research organizations, whether through programs initiated by subregional organizations (SROs) or by CGIAR research networks (Chapters 2 and 15, this volume), which has often limited the relevance of the research, the effective testing of improved technologies, and efficient deployment.

To ensure the effectiveness of agricultural research, NARIs in Africa south of the Sahara (SSA) need to be more outwardly focused and develop better linkages with principal actors in the agricultural sector. This is necessary for new knowledge generated by the NARIs to be effectively used, and relies on innovative capacity across the rural economy. Such a focus on innovation within the broader agricultural sector, primarily through improved market integration, communication, and institutional linkages across the different actors in the sector, has been formalized as agricultural innovation systems (AIS). Within the context of AIS, agricultural research is only one of a number of contributors to the rural innovation process; interactions among all actors are critical to ensuring and sustaining agricultural innovation across the sector.
This chapter explores the potential for organizing African agricultural research within an AIS framework. The first section evaluates the principal issues involved within the specific context of the region. The second section presents a concrete example of the approach in the form of a case study. Thereafter, the principal methodologies for bringing about this kind of organizational transformation are reviewed. Finally, existing examples of the region’s use of the AIS approach are reviewed to explore lessons learned to date.

**Agricultural Research within an Agricultural Innovation System**

Agricultural research is but one of a number of complex contributors to AIS, where the fundamental idea is to improve linkages between research institutions and other actors in the pursuit of agricultural growth and structural transformation. Within the context of an AIS, rather than a rigidly defined division of labor that governs interinstitutional relationships, stakeholders interact or “cluster” around a particular problem, often defined as an “innovation platform.” This interaction creates the conditions for effective problem solving, which in an African context most often revolves around improving smallholder productivity or incomes. This improvement can be realized through new technologies or improved access to markets, inputs, credit, or insurance.

Innovation operates through the application of new knowledge, enhanced organizational capacity, or changes in policies or institutions, all of which require effective coordination. Such coordination can be provided by fully functioning and interlinked markets. However, in African rural economies, markets are often underdeveloped, and coordination must be provided by other actors. The objective is to ensure the resolution of the problem, which in essence means being more responsive to farmers’ needs and providing the conditions for interventions to be effective. This requires changes in how agricultural research institutes view their roles, how they are organized, and how they link with other actors within the AIS.

**Extension as the Early Source of Innovation**

Prior to market liberalization in the 1990s, extension systems were seen as the unique source of rural innovation in African agriculture, offering a single organizational model in the form of the training and visit (T&V) system (Benor, Harrison, and Baxter 1984). The World Bank provided loans to more than 50 developing countries to adopt the T&V system during 1975–1998.
(Anderson, Feder, and Ganguly 2006). It was a top-down system, delivering a limited number of well-proven extension messages to communities through lead farmers. Moreover, links to agricultural research were managed at the national level and were rarely effective. T&V was both labor intensive and expensive; structural adjustment programs and the resulting controls on budgetary deficits essentially ended World Bank loans for T&V. The system ultimately succumbed to most of the design problems facing large, publicly funded extension programs: “scale, inadequate interaction with the agricultural research systems, inability to attribute benefits, weak accountability, and lack of political support” (Anderson, Feder, and Ganguly 2006, 2).

However, no fiscally conservative model existed to take its place, so a period of experimentation with extension methods ensued from the late 1990s and into the new century. Such experimentation was aided by the rapid expansion of nongovernmental organizations (NGOs) as a result of democratization and the strengthening of civil society in a large number of African countries. Many of these extension methods were based in rural areas and, to compete for funding, had to offer innovative approaches to improving farmers’ incomes. Many countries started with organic farming approaches, but also experimented with group approaches that built social capital.

A similar, but more widely disseminated, approach was farmer field schools (FFSs). This method was originally developed in Asia through the extension of integrated pest management and was introduced in East Africa in 1995 (Davis et al. 2012). The approach uses experiential learning in a group format, not only to familiarize farmers with new production techniques, but also to build social capital to empower them to continue to innovate. One study evaluating three countries in East Africa (Davis et al. 2012) found that FFSs were successful in improving both the productivity and the incomes of participating farmers, and that this applied particularly to female farmers and farmers with limited education. FFSs never evolved into a national agricultural extension system, however, partly because agricultural extension is one of the principal services to be included in district-level decentralization, so units could choose the extension methodology they deemed most appropriate. Similarly, the expanding private sector—often through the development of agro-dealer networks—also became a principal source of extension advice, particularly in terms of input management. These trends, together with the range of actors providing advisory services, led to the adoption of multistakeholder, pluralistic extension systems, where government was only one provider of such services.

Decentralization, multiple actors providing extension services, and the need for sustainable financing of extension motivated an experimental design
of an advisory services system in Uganda. The National Agricultural Advisory Services (NAADS) program was piloted in selected districts in 2001 and was designed around three principal elements: (1) developing structures (farmers’ forums) to articulate demand for advisory services, (2) meeting that demand through the provision of contracts to private advisory service suppliers, and (3) transitioning financing from public funds to farmers paying for services. NAADS invested significantly in training farmers’ groups as part of their participation in the program. Although there was quality assurance for agricultural service providers, at least one of two impact studies (Okoboi, Kuteesa, and Barungi 2013) found that poor-quality service provision was a principal reason for the lack of adoption of new technologies and limited evidence of improved crop productivity or agricultural incomes. The other impact study (Benin et al. 2011)—although not finding evidence for technology adoption—did find impacts on participant farms in increased crop and livestock productivity and agricultural incomes. In terms of financing NAADS, both farmers’ payments for services and contributions from local government remained insignificant. Possibly the two major constraints in the implementation of NAADS were the lack of effective capacity in agricultural service provision across the country and the problem of elite capture in awarding service contracts.1 Building effective rural innovation capacity at scale has thus remained a challenge in Africa.

Agricultural extension remains an area of continuing experimentation in terms of methods, principal focus on expanding links to the private sector, financial sustainability, and the use of information and communications technologies (ICTs). ICTs have expanded rapidly, involving such areas as rural radio (for example, Shamba Shape Up in East Africa), extension and market advice over cell phones, and the use of video (for example, Digital Green). These techniques are very cost-effective in reaching large numbers of farmers. Such platforms can sensitize farmers to production problems, market opportunities, or improved inputs, but large questions remain as to their ability to address location-specific needs and farmers’ ability to translate such information into changes in management practices, especially without the critical step of learning by doing found in more intensive methods, such as FFSs.

The evolution in extension methods and organizational models provides many of the preconditions for a more robust AIS and for enhanced rural innovation capacity. The experience with farmers’ groups, improved social capital,

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1 The president of Uganda called for the dissolution of NAADS in 2014, which would require parliamentary approval. The future of the program remains uncertain.
experimentation with methods, improved links with the private sector and other actors, the decentralization of capacity, and the testing of alternative financing models are all indicative of a more demand-responsive, flexible, and outward-looking capacity in providing advisory services. Nevertheless, this ongoing evolution will require the integration of new sets of skills, a better blending of new ICT approaches with learning by doing, and in the end better connectivity to agricultural research and sources of improved agricultural practices.

**An Evolving Role for Agricultural Research**

As discussed above, the move to organize research within an AIS comes at a time when agricultural extension is being reorganized using diverse methods and approaches. In addition, a decade after market liberalization, the private sector is investing in agriculture, thereby strengthening supply chains, developing input markets, and expanding agroprocessing capacity. These changes collectively provide both an opportunity and a challenge in terms of effectively coordinating the integration of smallholders into markets, improving their productivity, and increasing their marketable surplus, which is essentially the basis of most investment plans under the Comprehensive Africa Agricultural Development Programme (CAADP). Improving adoption of advanced technologies is directly linked to improved access to input, credit, and output markets, which requires approaches beyond traditional extension methods toward strengthening the capacity to innovate. This dynamic institutional context and the increased emphasis on results and accountability (Chapter 12, this volume) have expanded the roles of agricultural research, beyond just the production of scientific knowledge and development of technologies, into building innovation capacity.

Linking the extension of enhanced technologies to improving market access requires better links with the private sector, more effective collective action and farmers’ organizations, and innovative extension approaches and new skills. These requirements emphasize value-chain approaches in organizing innovation platforms, but at the same time they require something of an “honest broker” to integrate competing private-sector actors. NARIs, especially given the distribution of their research stations and status as autonomous parastatals, are in a position to play that role, given their internal capacity. As an example, the Kenya Agricultural Research Institute (KARI) has organized its research and outreach around priority value chains (Miruka et al. 2012). In taking this approach, KARI requires new skills in facilitating, organizing, and coordinating linkages throughout the innovation platform,
which in turn requires capacity beyond that needed to conduct agricultural research and development (R&D) programs (see the discussion of KARI in the last section of this chapter).

The need for new, “soft” (that is, facilitation) skills and improved capacity in such areas as facilitation, business development, farmers’ organizations, and communication raises the question of where such capacity should be developed within the sector. Extension would be a logical option, but would require a significant shift in skills and knowledge, especially considering that most extension personnel have limited (usually diploma-level) training. Some NGOs have the needed skills, and many could take on a brokering role between farmers’ organizations and private and public entities; however, their ability to deploy the necessary capacity would be limited geographically and by their dependence on external funding. With increasing accountability, agricultural research institutes are being nudged to take on this role. The question then becomes whether capacity should be built only in the larger systems. It can be argued that smaller research systems already function in a brokering role by accessing external sources of technology and adapting it to local conditions; that adaptation role could easily be broadened from a narrow focus on adaptive research to one of coordinating innovation platforms.

Research within an Agricultural Innovation System under Capacity Constraints

As previously noted, a fully functioning AIS in SSA is still under development. As Sumberg (2005, 24) argues, the intent is not an integrated system, but an interacting one, where “greater interaction or feedback between . . . actors makes a system more dynamic, which is manifest by the properties of robustness, flexibility, and the ability to generate and respond to change.” Using an AIS as a basis for institutional reform has shifted the debate away from an entity’s internal capacity to undertake relevant research, to its capacity to interact and link with other, functionally different actors in the agricultural sector. However, these two capacities are quite different in terms of skill sets, disciplinary mixes, and mobility, yet they must interact and complement each other within a research institution. As Horton (2012, 316) notes, research within an AIS requires “new competencies related to communication, participatory planning, facilitation of teamwork, and learning-oriented evaluation. Conventional capacity development has concentrated on developing the knowledge and skills of individuals, but research organizations that perform effectively in innovation systems also require changes in policies, management systems, and incentives.” This requires a rebalancing of competencies.
and changes in internal management and financial allocations to link internal research programs with external application—namely, innovation.

Positioning agricultural research in a more proactive role within an AIS thus requires leadership and a fundamental decision to improve the organization’s capacity to interact with other actors in the sector. Some research institutes adopt the position that the capacity to foster innovation exists in other organizations, so they can play a more traditional role. This is what Reddy, Hall, and Sulaiman (2011) refer to as “knowledge generation and adaptation,” as distinct from “knowledge application.” For those institutes where developing innovation capacity requires a more proactive role, the issue becomes where to train staff in these new skills, how to organize such capacity, and what percentage of resources to devote to it. For supporting staff, this would require short courses, but for program leadership, in most cases degree-level training is required.

The Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) has launched a PhD program in rural innovation, which provides both theory and practical skills, including soft skills, in this emerging field. The degree will be offered by Makerere University, Egerton University, and Sokoine University, and will draw on a student body from East and Southern Africa (Chapter 9, this volume). Nevertheless, for African conditions, few models exist to draw from regarding how to organize such programs—although Spielman, Ragasa, and Rajalahti 2012 review methodologies and various institutional arrangements in improving organizational interaction and linkages and Moock (Chapter 10, this volume) evaluates the potential of regional networks in building such capacity. Moreover, experience with the internal program organization of research institutes is minimal, possibly apart from the work by Mbabu and Hall (2012) in Papua New Guinea.

**Balancing Context and Scale in an Innovation Process**

Research within an AIS is applied quite differently across the developing world, depending on how well a country’s agricultural markets are integrated and linked to global agricultural markets, and how well the focal points for problem identification—that is, the matrix of professional, trade, commodity, and farmers’ organizations—are developed (Lynam 2012). In countries such as Chile or Thailand, where these conditions are met, research tends to (1) focus more on the use or agroprocessing end of the value chain; (2) be more effectively integrated with private-sector application; (3) be more basic, so as to feed into private-sector product development and give the industry a competitive edge when competing in the world market; and (4) focus on
broader-based transformation across the industry, defined either by commod-
ity or input, thus achieving some scale economies in application. This research
is often organized around a cluster approach, where “cluster-based policy aims
at removing the imperfections of innovation systems by enabling them to
function more efficiently and avoid coordination failures” (Theus and Zeng
2012, 396). Clusters form the platform for problem identification and innova-
tion, driven by a dynamic market environment.

Such market conditions are not met in SSA. Innovation tends to be
focused more at the production end of the value chain, where there is signif-
ificant public-sector participation and uncertain, often tenuous links to an
emerging private sector. Given the heterogeneity facing farmers in agroecolog-
ical, market, and institutional conditions, understanding context is critical to
the innovation process (Hounkonnou et al. 2006; Reddy, Hall, and Sulaiman
2011) and to the adaptation and application of knowledge. At issue within an
African context are how the innovation process is coordinated across the dif-
ferent actors, and how responsive it is to context. There is no “market for inno-
vations” (Sumberg 2005) to provide such coordination; at the farmer level, the
innovation process is usually facilitated, often involves enhanced commu-
ity-level innovation capacity (such as Triomphe 2012), and is often organized
within a value-chain platform. The heterogeneity of the farmer context gives
rise to the question of how to achieve sufficient scale in a facilitated innova-
tion process to cover the organizational, coordination, and transaction costs.

In many ways, ensuring effective approaches to scaling both research and
innovation processes in SSA is the core design issue for deploying both orga-
nizational capacity and programmatic investments. For large investors in
agricultural development in the region (such as the Bill & Melinda Gates
Foundation), this has become a critical design requirement for investments.
The approach to scaling the dissemination of input-based technologies tends
toward a relatively narrow set of technologies distributed through existing or
potential input markets. From an AIS perspective, problem solving within
a heterogeneous environment most often leads to localized solutions with
potential for farmer-to-farmer diffusion, but limited scope for spatial diffu-
sion. Neither a relatively narrow spatial scope to localized innovations nor
wide market distribution but irregular adoption of a narrow set of improved
inputs has the potential to meet the needs of African smallholder farmers.

This challenge has led to other approaches to attaining scale, which pri-
marily focus on developing better linkages and improved competencies of
actors within the AIS following two principal, but reinforcing, pathways
(Hounkonnou et al. 2006). One approach is to build enhanced social capital in
rural communities through more effective farmers’ organizations, community empowerment, or methods that enhance farmers’ innovation capacity. Methods include FFSs and the codesign of innovations (Triomphe 2012). The second pathway relies on organizational and institutional change to support the broader, more effective application of such methods, thereby targeting systemwide capacity and the formation of efficient organizational partnerships.

For African national agricultural research systems (NARSs), undertaking research within an AIS requires developing an efficient adaptive research capacity with links to innovation platforms that operate at a sufficient scale. An efficient adaptive research capacity explores agricultural heterogeneity through systematic site selection, characterization, appropriate trial design, integrated analysis, and extrapolation. Thus, ad hoc empiricism is replaced with information platforms that build systematically over time within cost-efficient, hierarchical designs. Such capacities do not exist in most NARSs. Adaptive research is costly, but NARSs have the potential to develop adaptive research networks across field capacities through NGOs, extension providers, and CGIAR centers, where a systematic design could substantially improve the value of the information generated. Such capacity can in turn be linked to facilitated innovation platforms that coordinate actors in the agricultural sector around particular problems, value chains, or agroecological zones. With decentralization of many public services, a relevant scale for coordinating actors and managing heterogeneity is the district level, especially given that NARSs operate through a distributed system of research stations. Nevertheless, successfully operating innovation platforms at this scale would require an effective organizational structure to reach out to and link farmers. Thus, information and farmers’ organizations are essential building blocks for achieving scale in the context of agroecological and socio-economic heterogeneity.

**Innovation Systems and Agricultural Development in Africa South of the Sahara**

Structural changes are occurring in both national and global food and agricultural systems. They include the integration of agriculture into global and regional markets, and the emergence of consumers as key drivers of technological change. Singly and in combination, these changes are fostering the development of AIS in Africa.

Recent moves to integrate African markets have been spearheaded by sub-regional economic blocs, with the goal of reducing tariffs and easing crossborder
trade. In addition, urbanization, the revolution in ICTs, and the emergence of a middle-income class are changing consumer preferences and demand. All have contributed to an expansion in agroprocessing and intraregional trade in higher-value products, including vegetable oils, processed milk, and milled flours, such as for maize, and canned vegetables and fruit juices. All of this requires restructuring of traditional value chains, where quality and timeliness of supply are critical to their effective functioning. The example of the seed potato value chain is presented in the Box 13.1.

**BOX 13.1 Actors in a seed potato value chain**

A project on developing seed potato value chains in Burundi, Kenya, and Uganda is being developed with support from the Association for Strengthening Agricultural Research in Eastern and Central Africa. Many actors are directly and indirectly involved, collectively making up an agricultural innovation system. Some actors operate at the *macro level*, meaning they help to provide an enabling environment within which the value chain can operate. Actors at the *meso level* provide services to the value chain and include research institutions that develop technologies, such as new seed varieties and other research outputs. *Microlevel* actors are directly involved in adding value to and moving the commodity along the pathway from production to consumption. *Product innovations* occur during the input and production segments of value chains; *process innovations* occur during the transformation phase, and *systems-level transformations* occur during the sales and distribution phase. Development projects have traditionally invested heavily in product innovations, but have paid little attention to either process- or systems-level innovations.

![Seed-Potato Value Chain Diagram](image)

**Micro level**
- Seed producers
- Certified/clean seed producers
- Chitting, packaging, and labeling entities
- Seed merchants
- Ware potato producers

**Meso level**
- Seed potato value-chain supporters, such as research institutes, community-based organizations, nongovernmental organizations, civil organizations, public–private entities, farmers’ organizations, and regulators

**Macro level**
- Local government and infrastructure and utility providers; national governments and ministries; and regional organizations

Source: Adapted from Nammuga (2013).
A development strategy that adopts an agricultural innovation framework represents a shift from a mode of simple technology delivery to one of strengthening the ability and capacity of actors in the agricultural sector to innovate. Five main agricultural innovation systems elements that support this are (1) technology aggregation, (2) knowledge and skills, (3) markets, (4) financing, and (5) an enabling environment.

Increased investments are needed to support innovations at the process and systems levels, especially in terms of adding value and linking farmers to markets. Such investments should target reforms in policies and legislation, institutional structures, and infrastructure development. Moreover, capacity-building interventions targeting individuals, institutions, and organizations are needed at the lower end of the chains (that is, at the farm and small-scale trade levels), which is inherently complicated, given the breadth and diversity involved. Capacity-strengthening interventions should aim to enhance the ability of the different value-chain actors to improve their interlinkages, as strong organizational linkages are an important ingredient for innovation.

Capacity development at the individual level should support farmers’ ability to adapt available technologies to their production environments and conditions. At the organizational level, farmers need support in developing effective organizations that enable them to profitably acquire inputs and information; access ways of collectively marketing their produce; and develop the necessary management capacities in the areas of human and financial resources, as well as ICTs.

Institutional linkages, the incentives to innovate, and greater responsiveness to consumer demand rely on well-functioning markets. Effective integration of smallholders into higher-value supply chains relies on such factors as higher-potential agroecologies, good access to road infrastructure, distance to principal urban markets, and location of processing infrastructure. Only a small minority of African farmers are located in such favorable market contexts. The majority of smallholder farmers face a number of constraints in terms of access to and integration into markets; availability of inputs, especially fertilizer; incentives for collective action; functionality of services, such as extension and credit; and, in summary, appropriate incentives for adoption of new technologies. Farmers thus tend to focus on the production of basic food staples, with a significant portion maintained for subsistence.

AIS approaches adopt a more holistic approach to resolving such interconnected production, organizational, and market constraints, but with an inherent bias toward those farmers and locations where market potential is more developed. A basic question is how AIS approaches can be adapted to the
particular conditions of African agricultural contexts in order to reach the
greatest number of farmers.

Innovation Methodology at Different Scales

Building on Systems Methods

AIS practice in Africa is still evolving. It has its roots in a number of inte-
grated systems methodologies that have been developed over the past couple of
decades. In Latin America and Asia, such systems focus on upstream research
that supports agroenterprise clusters higher in the value chain. In contrast,
AIS approaches in Africa focus on facilitating farm-level innovation, but are
usually linked to commercial or market opportunities. AIS approaches do not
exclude objectives related to food security or farming-system resilience, but
methods for addressing these objectives are not as well developed, and coordi-
nating their development and application at scale will be more difficult com-
pared with value-chain approaches.

Agricultural innovation methods build on the trend since the 1990s
toward more integrated approaches, particularly in achieving impact with
R&D in natural resource management (NRM) (Hagmann et al. 2002).
NRM-related R&D was based on systems approaches, was context specific,
relied on tools and methods rather than physical technologies, involved farmer
participation and adaptive management approaches, and was facilitated by
a range of institutional actors. Since 2000, CGIAR has moved to formal-
ize these methods and approaches and to integrate productivity and NRM
research and application (Campbell and Sayer 2003; CGIAR Science Council
2003). While this effort has resulted in a set of principles and approaches, it
has not had widespread application and, thus, is lacking an evolving commu-
nity of practice.

Within CGIAR, integrated natural resource management (INRM) was
overtaken by the development of challenge programs, and in Africa by the
response to the 1990s market liberalization process. In attempts to link small-
holder farmers to markets, the slow response of the private sector to the with-
drawal of state agencies from input supply and output marketing resulted in
an expansion of facilitated approaches. These approaches usually involved
interventions at various points in value or supply chains and, as such, usu-
ally involved a commodity focus. Market access thus provided the incentive
environment for farmers to adopt improved technologies. Nevertheless, given
the commodity orientation of such value-chain approaches, new technology
targeted productivity increases, thus moving away from INRM’s focus on systems and resource management.

All of these elements came together in the design of CGIAR’s SSA Challenge Program in what was termed Integrated Agricultural Research for Development (IAR4D). The design of this program in 2003 built on the foundations of INRM in linking productivity and NRM research; at the same time, however, it added research on markets. All of these elements were deemed necessary for developing smallholder agriculture and achieving what has more recently been termed “sustainable system intensification.” The intent was to improve the integration of agricultural research and, hence, the impact on development outcomes, which required crossing traditional institutional boundaries, particularly between research and extension. The characteristics of IAR4D were defined by Hawkins et al. (2009, 3) as follows:

- IAR4D is about change or innovation as an outcome, not just about information, knowledge, or technology as a product;
- IAR4D places “research” as one of the components contributing to the development process, rather than its pivotal point;
- IAR4D focuses on processes and performance rather than just products (technologies, policies)—or, to put it another way, improved processes are the product.

As such, IAR4D was completely integrated into evolving ideas in the development of AIS, as was exemplified by the SSA Challenge Program (which is discussed in more detail later in this chapter).

**Marrying Theory with Organizational Change and Methodological Practice**

AIS/IAR4D practice continues to evolve and, hence, has succeeded where INRM effectively stopped. Much of this work is carried out by CGIAR centers or northern universities (Hounkonnou et al. 2012). The research, per se, focuses more on methodology and adaptive research than on traditional applied research. AIS methods are thus a bridge between developing technologies or managing components (such as varieties or soil fertility practices), and applying, adapting, or integrating them into farming systems. This is partly because the methods focus on identifying problems at the farming-system or community level, and, to maintain momentum in the innovation process, an initial testing of potential “on-the-shelf” technology options is required. However, the intent is to combine the farm-productivity
dimension with institutional and organizational innovations that significantly change the possibilities and incentives available to farmers. Organizational innovations require the involvement of other actors in the agricultural sector, often at (but not limited to) the district level. As previously discussed, such organizational linkages are facilitated through innovation platforms (Nederlof, Wongtschowski, and van der Lee 2011).

In a recent systematic review of capacity strengthening in agricultural research, Posthumus, Martin, and Chancellor (2012, 1) found that “at the level of national agricultural research systems (NARSs), investments need to be made in strengthening relationships between research, extension, higher education, civil society, the private sector and farmer organisations to enhance innovation.” The AIS approach shifts the focus of capacity strengthening from internal organizational reforms and human capital to improvements in organizational linkages. Spielman, Ragasa, and Rajalahti (2012, 277) note that “there is a case for both market and nonmarket approaches to improving demand articulation and organizational interfaces [in agricultural research systems]. They include investment in formal mechanisms that provide stakeholder input to research organizations, more participatory mechanisms that bring researchers and farmers together to solve problems, innovation platforms that address larger, more complex challenges with diverse actors, commercialization programs that move research into the marketplace, and financing mechanisms that encourage collaborative research.” That is, NARI approaches to improving institutional linkages can be implemented incrementally, adding increasing complexity and building on experience and learning over time.

The core AIS concept, which dynamically involves core agricultural sector actors in the research process, has been tested in a few countries, but the results suggest a low degree of integration of research within the larger system. Spielman and Kelemework (2009, 6–8 and 22) evaluated interactions across four principal categories of actors (that is, domains) within the Ethiopian AIS (knowledge and education, bridging institutions, business and enterprise, and an enabling environment), and found that the interactions were primarily within individual domains (for example, private-sector actors). In terms of interactions across domains, “while respondents from all domains were satisfied with linkages with bridging institutions (in this case, linkages with public extension services), they were largely dissatisfied with their linkages with collaborators in all other domains, particularly the knowledge and education domain (in this case, public research organizations and institutes of higher learning).” This lack of interaction in the area of research was confirmed in Ghana and Nigeria (Ragasa, Abdullahi, and Essegbey 2011, 17), where in
Ghana “less than 30 percent of researchers in [research] institutes and faculties reported being involved in research–extension linkage committee (RELC) activities. Half of these organizations said that less than 10 percent of their researchers were involved in RELCs. A survey of 237 agricultural researchers suggests that 87 percent were not involved in RELCs.” This trend was reflected in interactions with other domains—including farmers, with whom almost a quarter of researchers had not interacted in the past year.

An AIS perspective highlights the relatively autonomous functioning of NARs in Africa. Moreover, as Mbabu and Ochieng (2006, 8) note, “many publicly funded agricultural organizations in Africa—such as agricultural research organizations, universities, extension services, and farmers’ organizations—are facing a crisis of confidence among key stakeholders arising out of the failure to deliver the desired development impact.” In an African context, the production of technologies by NARs is not sufficient to produce the increases in smallholder productivity that are essential for economic growth. This is not a call for yet another major reform of African NARs, but rather for developing the necessary leadership, organizational incentives, and shared vision, recognizing that joint action produces synergies far greater than can be achieved independently. Yet, significant transaction costs are involved in facilitating these organizational linkages and the financial and logistical resources required to support such mechanisms. In addition, new (primarily soft) skill sets are needed to facilitate these linkages, and whether these skill sets should be developed within NARs or provided by other, more specialized organizations depends on context.

The Centrality of and Capacity in Adaptive Research

To develop the foundation to improve organizational linkages and function within an AIS, NARs need to build their relative comparative advantage—producing new knowledge and technologies. However, research stations do not provide an effective locus for developing and managing organizational linkages. Adaptive research trials are a principal activity around which such linkages can be initiated. They are not only essential for dealing with the heterogeneity and scalability issues, as discussed above, but also provide a mechanism for interactions with farmers; developing a dialogue with extension providers; testing private-sector inputs, particularly varieties and fertilizer blends; and providing links to market agents and credit agencies. If properly designed, adaptive research trials can be integrated into more complex organizational mechanisms, such as innovation platforms, or can act as an initial bridge to wider interactions with other actors in the agricultural sector.
The N2Africa program has been initiated with demonstration and adaptive research trials as its core activity (Giller et al. 2013, 165):

N2Africa focuses on the delivery and dissemination (D&D) of the best available nitrogen N2-fixing legume technologies . . . . Monitoring and evaluation (M&E) seek to understand why certain technologies work best for particular farmers, and feedback loops through adaptive research seek to refine and improve the technologies through addressing those problems that emerge. Thus, the emphasis is on improving N2-fixing legume technologies, solving problems encountered in the field, understanding how to tailor technologies to different farms and farming systems and using this understanding to refine D&D.

Understanding how to efficiently adapt technologies to different farming systems and agroecologies is a necessary first step in facilitating innovation and adoption by farmers. Where more complex technologies are involved, especially working with several components in a farming system, these trials could evolve into more participatory technology design and codesign with farmers (Triomphe 2012). This would require trade-offs between systematic data collection and location-specific adaptive management and learning, but the trade-offs could be managed as long as the researchers and farmers were clear about the objectives of the trials.

Adaptive research trials can thus become the basis for articulating demand, with researchers interacting with farmers to diagnose problems, then developing a location-specific understanding of the principal productivity constraints and yield responses to technological and management interventions. If done systematically—for example, through agroecological and socioeconomic stratification of the target area and population—NARIs could develop their understanding of the heterogeneity of yield responses and the potential for adoption, while enhancing their interactions with farmers over time. The basis for scaling the results would also exist to the extent that an organizational structure for farmers was in place. Alternatively, close linkages with extension services would allow recommendations to be targeted more precisely. Moreover, variations in farmers’ circumstances could be incorporated as a basis for managing heterogeneity, rather than relying on national- or even regional-level recommendations (such as those used for fertilizer combinations and rates).

A systematic adaptive research network could not only feed information back into the research design process, but also feed critical information forward to rural credit and insurance schemes and to market agents. Production credit and insurance rely on understanding productivity responses under
temporal and spatial variability. Moreover, agroenterprise investors need to understand the farm-level costs of production, farmers’ supply responses, and seasonal variability. Location matters in their investments in terms of logistical and raw material supply costs. Thus, research can offer critical insights to an innovation platform, in essence supplying the public goods that justify public investment. Such capacity comes at some cost, however, in terms of operating budgets, which tend to be the most insecure, in terms of both the amount and the time of release, given that adaptive research is time sensitive if the resulting information is to be accurate. Therefore, an AIS is based as much on product and information flows as it is on organizational linkages and processes. In effect, these two aspects complement each other.

**Emerging Experience with Agricultural Innovation Systems in Africa South of the Sahara**

Effectively positioning national agricultural research in SSA within an AIS presents a number of constraints. A functional AIS relies on the following characteristics:

1. a sufficient array of institutions that are networked and have the necessary capacity;
2. deep entrepreneurship and innovation capacity, usually driven by well-functioning markets;
3. facilitated or self-organizing organizational platforms that permit effective networking; and
4. finances that cover the transaction costs inherent in the networking process.

Innovation primarily arises from interactions among the different actors within these networks—for example, among trade associations, farmers’ organizations, and agricultural research institutes (Hall, Dijkman, and Sulaiman 2010a). However, the region’s agriculture sectors are generally characterized by underdeveloped input and output markets; weak or nonexistent service delivery organizations (particularly in terms of rural credit and insurance, but also extension services in many areas); an emergent private sector; and a large smallholder sector that is only just developing a commercial orientation.

Given these constraints, the African experience with AIS approaches tends to focus on developing the innovation capacity of smallholder farmers, is facilitated by external agencies, is primarily led by international research
organizations, and is developed in the context of multicountry projects. The fodder adoption project is a good example, whereby a consortium of CGIAR centers used an innovation systems approach to support innovation in the use of fodder technologies by smallholders. This was a facilitated approach focusing on developing innovation capacity by (1) strengthening weak ties among actors, (2) filling organizational gaps, (3) strengthening the supply system for fodder seeds, and (4) interacting with policymakers to improve policies (Ayele et al. 2012).

Strengthening networks and filling organizational and market gaps are characteristic of AIS approaches in Africa and lead to the question of how these approaches can be appropriately scaled. A review of the experiences of four African programs that use an AIS approach follows.

**Research into Use**

The Research into Use (RIU) program of the UK Department for International Development was specifically designed to put the scientific results of the Renewable Natural Resources Research Strategy (RNRRS) program into practical use by farmers at a relevant scale. The program’s focus was on the actual application of knowledge, rather than the generation of knowledge (Hall, Dijkman, and Sulaiman 2010b; Clark 2013). RIU was launched in 2006 and ran for five years—a period too short to demonstrate significant farm-level impact at scale, especially given changing objectives after a midterm review. The RIU program’s initial design was technology led, essentially applying on-the-shelf technologies resulting from the program. However, over the course of the RIU program, the activities were framed within an innovation systems perspective, to maximize learning from the program and ensure private-sector participation (Clark et al. 2012; Clark 2013).

The organization of the RIU program in Africa involved two program strands comprising seven country programs and a competitive “best bets” grant program.² The national programs also had two prongs: developing a national innovation coalition and facilitating the development of innovation platforms, essentially organized around specific commodity value chains. The national innovation coalition was primarily designed to support capacity strengthening in the innovation process, especially in terms of facilitating the development of innovation platforms and assisting farmers with communicating their concerns. The innovation platform aspect initially had a technology

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² Best bets refers to technological options determined to have the best potential to move on to farmer testing and adoption.
focus, but evolved into commodity value-chain platforms, in many cases focusing on farmers capturing an increasing proportion of the value-added in the supply chain.

The innovation platforms tended to be organized at the district or state level, although in Malawi they were organized at the national level. The composition of the innovation platforms also varied significantly, with much broader participation of different actors in Nigeria, but much greater involvement of farmers’ groups and NGOs in Malawi and Rwanda, as well as much more focus on production, the market, and adding value. Research institutes also participated (especially in Nigeria), but they did not lead the facilitation of innovation platforms. The dominance of farmers’ groups in Malawi and Rwanda often resulted in too much of a bias toward farmers’ interests at the expense of viable business models in the supply chain (Gildemacher and Mur 2012).

The RIU program explicitly separated rural innovation from research, following a more linear model of first funding research under the RNRRS program and then applying that research in the RIU program. In effect, the application was driven by the available research products. In an evaluation of the RIU program, Gildemacher and Mur (2012, 166) note that, at least initially, the program went “against the principles of needs-driven research, and of making use of multiple sources of innovation. Rather than starting with the open question of needs and then engaging in a wide search for possible solutions from different sources, pre-conditions were set that reduced the chances of effective innovation.” The evaluation assessed the different innovation platforms and best bets in terms of farm-level impacts and the development of innovation capacity. Although the five-year timeframe limited the potential for drawing conclusions, the evaluation focused on five cases and found that in one case there was significant impact but limited innovation capacity (Nigeria), while in another there was significant innovation capacity but limited impact, at least to date (Rwanda). This suggests that where preconditions of markets and effective institutions are in place and agroecologies do not vary (as in Nigeria), technology is adopted at scale (as in the Green Revolution). Such conditions are still relatively rare in SSA, however, and building innovation capacity linked to multiple sources of technology provides an entry point into broader-based agricultural development, although as Gildemacher and Mur (2012) note, what remains lacking is a framework to do this at a larger scale.

The SSA Challenge Program
The SSA Challenge Programme (SSA-CP) was a CGIAR response to developing a research program across CGIAR centers focusing on smallholder development
in the region. The design of the program built on the methodological synthesis in INRM and attempted to integrate the increasing work on smallholder market access following market liberalization in the 1990s. The conceptual framework became known as IAR4D. The original intent was to directly link to the evolving conceptual thinking in AIS using a demand-driven farmer approach to establish system entry points and set the research agenda. However, the CGIAR Science Council found this open-ended process antithetical to ensuring high-quality science. A succeeding round of interactions between program management and the CGIAR Science Council resulted in a program design that would test the relative effectiveness of IAR4D using a randomized experimental design applied within three well-defined benchmark sites in West, East, and Southern Africa (Lynam, Harmsen, and Sachdeva 2010). The central methodology employed within IAR4D was the facilitation of innovation platforms.

The organization of the platforms varied somewhat across East, West, and Southern Africa, but was essentially focused at the subdistrict level because it facilitated the experiment’s design by providing a framework for randomization. The platforms drew on representatives of farmers’ groups, key market agents, and local government officials. A hierarchical approach to farmers’ involvement enabled a cascade approach to building capacity and providing services to farmers’ groups.

The innovation platforms were facilitated by university and extension personnel working with CGIAR centers, with a continuing question of how formalized the platforms should be, particularly, to interact with local government. In East and Southern Africa, the entry point for the innovation platforms was access to markets, where resolving that issue would lead to farmers’ demand for new technologies. In West Africa, where the benchmark site was dominated by Nigeria, markets for principal crops were not viewed as a constraint, so the entry point focused on access to improved production technology. In all cases, the programs sourced on-the-shelf technology. Integrating productivity-enhancement techniques with improved NRM proved challenging within the time constraints of the program. These different entry points led to significant differences in the mix of participants in the platforms.

The role of agricultural research institutes in facilitating innovation capacity has been debated in AIS literature, particularly in terms of whether research institutes would bias innovation platforms to their own interests, and whether technology should take the lead as an entry point into the rural innovation process. CGIAR centers acted as “honest brokers” in facilitating the development of the platforms, with a research interest in evaluating how to achieve development outcomes more cost-effectively. The brokering role was critical in creating
a neutral platform for identifying problems and developing potential solutions. Given the rural locus of the innovation process and the role that improved technologies play in rural innovation, such agricultural research institutes as CGIAR centers are well placed to facilitate the development of innovation platforms, because they have the necessary skills and operating budgets. However, only the larger NARIs would likely be in a position to develop the necessary skills and operating capacities. Alternative organizations that have both of these capacities are relatively limited in an African context, although in many cases, international NGOs are moving into this existing gap. The experience of the SSA-CP suggests that research institutes can play a leadership role in an AIS, but such facilitation is not necessarily limited to research institutes.

In an African context, innovation platforms should focus on cost-effectively facilitating rural innovation capacity at a sufficient scale, but also at a sufficiently contextualized local level. Finding this balance and creating the public funding that supports the inherent transaction costs involved should be a priority. Another priority is the need to design innovation platforms and build the capacity to facilitate their development. The SSA-CP had these priorities as a principal research objective, although it was not possible to vary scale because of the experimental design. As with many evaluations of organizational innovations, there was an inherent difficulty in adequately specifying the counterfactual. Moreover, the SSA-CP was critically time constrained, and funding was insufficient for the program to complete an adequate implementation period to evaluate effectiveness, within about two years.

Initial findings, however, suggest increased adoption of crop management technologies in innovation platform-facilitated communities compared with a control community. This was not true for soil management or postharvest technologies (Pamuk, Bultea, and Adekunle 2014). Moreover, bottom-up innovation platforms, as measured by variation in priorities across communities, tended to be more successful in facilitating adoption compared with top-down innovation platforms. Unfortunately, most of the African programs that are testing an AIS approach are project based, and securing multiyear funding has been a major constraint to effective implementation.

**The African Highlands Initiative**

In many ways, the African Highlands Initiative (AHI) developed the methodological underpinnings and practice of the principals underlying INRM. Its advantage in comparison to similar work in Africa is that it operated for a relatively long time by current project standards (from 1995 until 2008), after which components of the program were absorbed into the World Agroforestry
Centre’s East Africa Regional Program. The evolution of the program over this period incorporated the conceptual thinking surrounding IAR4D and the AIS. The AHI organized its activities around benchmark sites across five countries, with an experiment in scaling out impact into other sites at the end of the program.

AHI’s principal focus was NRM within the high-population-density areas of the East African highlands. In its first phase, the research targeted principal farming systems, so it had to be combined with improved productivity. The second phase expanded the scope and scale of research to watersheds, which involved an understanding of community-level collective action and developing broader governance and decisionmaking mechanisms. The work went on to look at how to integrate these institutional innovations at the district level. Much of the research resulted in developing methods at different scales and understanding interactions among technological change, market access, farmer investment in the natural resource base, institutional and governance innovation at the watershed and then the district level, and links to policy reform (see German et al. 2012 for a review of the program’s work). Given the relatively long-term involvement in each of the benchmark sites, the final phase was designed to test whether both the soil and land management approaches could be scaled out to other districts.

AHI worked from farm to watershed to district levels, thereby integrating technical change, watershed management, and policy. However, scaling out technical innovations and scaling up institutional and policy innovations beyond the benchmark sites and districts proved to be more difficult and time constrained (Opondo et al. 2012). The AHI did this by developing interlinked innovation platforms at the watershed and district levels. An evaluation of this stage (Amede 2012) suggested that the watershed-level innovation platforms functioned well in the scaling out of technical innovations and sustainable land management techniques. However, they performed not as well at the district level, primarily because district government participation introduced incongruent interests. Unfortunately, this key issue was not tested further. The critical constraint, however, appeared to be the need for institutional change, district-level buy-in, and expanded participation in the district-level innovation platform by other soil- and land-management stakeholders.

Reform of Kenyan Agricultural Research

The dominance of international and regional actors in the testing of AIS approaches in Africa demands an assessment of the uptake of these ideas by NARSs and NARIs. Kenya provides an ongoing example of this process
because it has undergone systematic policy reform within the agricultural sector, including research and extension. This reform has been seen as an integral aspect of economic transformation, starting with the Strategy for Revitalizing Agriculture (2004–2014), which was recently superseded by the Agricultural Sector Development Strategy (2010–2020). The 2010–2020 strategy is aligned with the CAADP process and provides the framework for finalizing new agricultural research and agricultural extension policies. The CAADP Compact resulted in the Medium-Term Investment Plan for 2010–2015 (Government of Kenya 2010), which prioritized investments across CAADP’s four pillars; yet only 1 percent of the overall investment budget was earmarked for research and extension (Pillar 4). The problem of underfunding is recognized in the 2012 National Agricultural Research System Policy (Government of Kenya 2012, 15): “Government funding has been directed primarily to maintaining the core functions of public research institutes. Over recent years, foreign assistance has taken an increased share in funding both core functions and stand-alone projects. . . . The overall funding base for agricultural research remains fragile and unsustainable.”

Nevertheless, the strategic focus of the 2010–2020 strategy and 2012 research policy was to commercialize smallholder agriculture, generate a yearly growth rate in the sector of 7 percent, and transform the sector to one that is essentially market driven. This would require significant increases in smallholder productivity. The investment gap for agricultural research is being filled by the World Bank–supported Kenya Agricultural Productivity and Agribusiness Program (KAPAP) and for extension by KAPAP and the Swedish government. At the same time, the Government of Kenya (2010, 13) notes the significant challenges in meeting these goals: “Asia’s Green Revolution took place within the context of irrigated specialized agriculture, stabilized prices, public provision of subsidized inputs, assured markets for farm outputs, and cheap credit. In contrast, Kenya must achieve a largely market-led agricultural transformation within a context of mostly rainfed and highly diversified smallholder agriculture, high-cost agricultural input and output marketing, volatile prices, inefficient land, labor and credit markets, and a vibrant but relatively low-capacity private sector.” These binding constraints on agricultural growth have informed the policy process through the recognition of the importance of organizational, institutional, and technological innovation in transforming smallholder agriculture.

The policy focus on commercializing smallholder agriculture has resulted in a priority-setting process based on commodities and an implementation process
based on value chains. Thus KARI’s approach to adaptive research is value chains for agricultural products, with a particular focus on partnerships, markets, and gender (Miruka et al. 2012). In research policy, value-chain and AIS approaches are directly integrated: “Some entities are embracing the concept of an ‘Innovation Systems Framework’ within which the agricultural product value chain and the Integrated Agricultural Research for Development (IAR4D) are included. This new approach seeks to (1) promote vertical coordination and horizontal integration within and among commodities, (2) fill in the missing nodes in the value chain continuum, and (3) improve linkages among research, education and extension. In Kenya, successes recorded in some areas such as horticulture, tea, banana, and dairy production show that in commercial commodities where the stakeholders are systematically consulted, the research agenda can be better focused and deliver impact” (Government of Kenya 2012, 11).

KARI’s adoption of the commodity value-chain approach has led it to develop further capacity in marketing and, more recently, in facilitating local innovation platforms essentially based on commodity value chains (Makini et al. 2013). Scope is addressed through the future development of these innovation platforms regionally and nationally, also within a value-chain framework. Moreover, the move toward an AIS was complemented by policy changes in agricultural extension through the National Agricultural Sector Extension Policy of 2012. Extension was devolved to the counties with the intention of improving service provision by allowing farmers to choose the provider. Under KAPAP, extension focuses on particular value chains in pilot counties through farmers’ “common interest groups.” The elements of an AIS are in place, but county capacities are just being established, and the extension system has yet to be fully scaled out. KARI is also being reorganized under the new research policy, and government commitment to fund research and extension remains elusive.

Kenya’s move toward a more fully integrated AIS has been led by an interconnected policy reform process embedded in larger political reforms under the new constitution, facilitated by both CAADP and KAPAP. The eventual impact, however, will depend on implementation. Some argue that a commodity value-chain approach stalls reform in commodity parastatals (Poulton and Kanyinga 2013). There is also the risk that relying on commercial, market-driven approaches will not have the requisite impact on balanced growth, food security, and poverty reduction within an agricultural sector that has high poverty rates, constraints on farm size, and a significant area in marginal agroecologies. The question of how to build these objectives into an evolving AIS in SSA remains a critical issue.
Conclusion

AIS approaches have shifted the capacity-strengthening debate on agricultural research in Africa from how NARIs are internally organized, to how they effectively link to other actors in the agricultural sector and how the new knowledge they generate is applied within a smallholder context. The AIS approach sets the objective of increasing smallholder productivity in the context of market-driven rural development, given high market-access costs, evolving input markets delivered at relatively high prices, incipient rural credit and insurance markets, and a reforming extension capacity. NARIs provide necessary but insufficient inputs into the rural innovation process; to ensure the adoption of new technologies and management techniques, they must interact with an expanding private sector, an increasing array of farmers’ and civil society organizations, and reforming public-sector service providers. Market liberalization and democratization have been the principal drivers in this dynamic process, and agricultural research has an opportunity to move from a state of near isolation to developing essential organizational linkages for rural innovation and smallholder development.

A functional, national AIS is currently only emergent within a few African countries, based on pilot and methodological work by primarily international entities and a desire by a number of principal donors to structure their funding around innovative approaches. The Kenyan case suggests one course through a holistic and coordinated policy reform process, in part reflecting opportunities available through a new constitution. However, the impacts of such reforms are only achievable through effective implementation requiring financial resources.

Organizing research within an AIS requires developing new capacities and skill sets, reviewing internal organization, and expanding field-level operating capacity. In summary, organizing research around an AIS requires increased operating budgets, but government funding for research remains limited and highly dependent on external sources. The chicken-and-egg question remains of how to demonstrate impact to justify increased funding, when increased funding at critical junctures is necessary to produce those impacts. The challenge in moving this agenda forward will be in progressively demonstrating pilot-level impact to justify funding for expanded implementation. The failure to provide sufficient funding to adequately test the AIS approach in SSA-CP, even with initial positive results, is yet another example of an opportunity squandered and the perception that the approach is ineffective.

From a methodological perspective, two principal limitations are inhibiting the full development of the potential and effectiveness of AIS approaches.
The first is the need to move beyond innovation platforms organized around value chains. The value-chain approach has natural organizational logic, but it neglects noncommercial, mostly marginal agroecological zones, the enterprise complexity of smallholder farming systems, the balancing of food security and poverty objectives, and the longer-term investments needed to ameliorate degradation of the natural resource base. Second, the AHI demonstrated that it is possible to improve NRM, but it requires very different techniques and a much longer time period. Moreover, the more recent focus on sustainable intensification in smallholder systems requires more of a farming-systems perspective rather than a focus on a single commodity. A commercially viable cash crop can provide a suitable entry point in the innovation process, but it needs to be integrated into the rest of the farming system, particularly with the objectives of improved resource use efficiency and sustainable resource management, especially of soil, water, and trees.

Finally, given the budgetary constraints under which these approaches will be deployed, cost-effectiveness will depend on balancing heterogeneity, context, and scale. Given that innovation platforms involve facilitation with high transaction costs, spreading these costs at a scale that does not neglect farmer and market heterogeneity will be a critical balancing act. Understanding context heterogeneity more rigorously using spatial analysis tools and being able to allocate scarce organizational resources in relation to that understanding is one way of improving program efficiency. This will also involve more systematic approaches to adaptive research, as well as a better understanding of how to effectively build innovation capacity in rural settings. The most important factor in moving AIS approaches forward, however, will be in testing and comparing implementation options in terms of innovation platforms, innovation brokers, and scale. This will increase program costs and fuel the investment versus evaluation conundrum, whereby on one hand donors want to limit resources to just supporting implementation of programs, but on the other they want to increase the evidence of impact. African AIS are currently straddling this particular fence.

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