Comparison of frameworks for studying grassroots innovation: Agricultural Innovation Systems (AIS) and Agricultural Knowledge and Innovation Systems (AKIS)

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ABSTRACT

The history of agricultural research and development (R&D) has never been static. Its philosophies, concepts and principles continue to change and to impact on present-day practices. It is imperative to understand and draw lessons from the old and new perspectives, which inform agricultural R&D processes and policy formulation in developing countries. The interest of this paper is, therefore, to draw relevant lessons that can explain the dynamics of the innovation systems at the grassroots in sub-Saharan Africa in particular. It analyzes the adequacy of two widely known agricultural R&D perspectives and examines how those perspectives could be applied to the grassroots innovation systems in sub-Saharan Africa, which are often characterized by subsistence agriculture, complex issues around the notion of poverty, environmental problems, and limited access to national and international markets.

The Agricultural Knowledge and Information Systems (AKIS) and the Agricultural Innovation Systems (AIS) perspectives are the main focus of analysis in this paper, which is organized to look into the epistemological and methodological aspects of those perspectives, describing briefly their differences and complementarities as well as their relevance to study grassroots innovation systems in sub-Saharan Africa. “Relevancy” of the AIS and AKIS perspectives to grassroots innovation systems cannot, however, be adequately explained and analyzed just by reviewing literature on theoretical discourses and frameworks. It is necessary to look at practice. Although it is not easy to find ”representative” case studies that could properly demonstrate application of the thoughts, assumptions and principles of the theories, this paper has reviewed two recent studies that raise critical issues. This review seeks to understand how AKIS and AIS perspectives are used in the real-world situation of smallholder farmers and the overall innovation system in developing countries. It is based on an analytical and comparative study of AKIS in several mainly developing countries, commissioned by FAO, and a study on AIS in six developing countries, commissioned by the World Bank. The latter covered 12 case studies on selected enterprises. Five of the case studies were reviewed to extract lessons on AIS. The links of the theoretical discourse and the practical experiences coming out of the two studies provide indications as to what is most relevant to the situation of the grassroots innovation systems in sub-Saharan Africa.

Keywords: innovation systems, innovation theory, agricultural research, smallholder farmers, sub-Saharan Africa

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GRASSROOTS INNOVATION IN SUB-SAHARAN AFRICA

"Grassroots agricultural innovation system" refers here to the interface of endogenous and exogenous innovation in the farming systems of smallholders, pastoralists and agro-pastoralists, referred to henceforth as "farmers". In these systems in sub-Saharan Africa, the economic base is usually subsistence agriculture. Great natural resource challenges affect the lives of the resource users and their actions, in turn, affect the environment. Since the local people struggle tremendously to survive and external forces of various interests are intervening strongly, there are complex dynamics of exogenous and endogenous innovation. "Exogenous agricultural innovation system" refers to all innovation interventions into the grassroots system that are initiated and controlled mainly by outsiders and intended to improve local livelihoods and the environment, e.g. the interventions of research, extension, the private sector, NGOs, financial organizations etc to introduce new technologies, new methods, new services, products, processes, and new institutional arrangements. "Endogenous agricultural innovation system" refers to new initiatives and innovation processes of the local people (groups or individuals), trying to address the issues of poverty and the environment and includes the interwoven interactions of the technical, institutional, marketing or management innovation performances of the local people. Exogenous or endogenous innovation systems differ primarily according to the sources of the innovations and the goals of the actors involved. In real-life situations, it is not common to see an independently standing endogenous innovation system or exogenous innovation system. A mix of both is typical for many of the grassroots innovation systems in sub-Saharan Africa.

RECENTLY EMERGING PERSPECTIVES ON INNOVATION SYSTEMS

Agricultural Knowledge and Information Systems (AKIS)

The AKIS perspective emerged as a response to the challenges of the theory of adoption and diffusion of innovations, which was preoccupied with studying why and how people come to adopt or not to adopt new agricultural innovations and practices (Leeuwis 2004). The National Agricultural Research System (NARS) perspective was founded on the theory of transfer, adoption and diffusion of technologies. It has long been used in many countries and. the use of this model is not yet "history"; it still continues to dominate in many institutions of the developing world. The legacy of the relatively remarkable success of the "Green Revolution" in agriculture of India and other Asian countries continues to influence many policymakers, researchers and extension institutions in the developing world, especially in sub-Saharan Africa. The linear technology-transfer model provides a huge opportunity for the accumulation of power at the centre. Politicians and policymakers whose governments are characterized by centralized control of power and a command economy tend to adopt this linear model, as it enables them to control the system comfortably, without having to be involved in the complex knowledge generation and utilization systems of the real world. For these reasons, it is not easy for a paradigm shift to take place in many of the developing countries, although the theorization of AKIS has tried to overcome the limitations of the NARS perspective and the subsequent policy and institutional arrangements.

AKIS is a result of a large number of "formative experiences" of applied social scientists who have tried to come to grips with the complex phenomena of facilitating innovation, primarily in agriculture (Röling 1996). The concept of AKIS was developed by Röling in the early 1990s as a diagnostic framework that helps to discern the organizational forms that enable or constrain knowledge processes such as generation, transformation and use of knowledge and information (Engel 1997). It is broadly defined by Röling (1992) as "… the articulated set of actors, networks and organizations, expected or managing to work synergically to support knowledge processes

which improve the correspondence between knowledge and environment and/or the control provided through technologies use in a given domain of human activity…"

AKIS demands a radical policy shift from strengthening research or extension institutions to strengthening linkages and communication that should take place among the system actors. Unlike in the NARS perspective, in AKIS farmers are not merely receivers of technology from research organizations via extension. The new actor configuration in AKIS suggests: all system actors have a stake in the process of generating, disseminating and using knowledge. Learning about the stock of knowledge in the system actors and creating a platform for the interaction of the actors to facilitate the generation of new knowledge and utilization of same, are the main principles in AKIS. The emerging and extensive use of many participatory approaches to R&D (such as Participatory Technology Development, Farmer Field Schools, Participatory Innovation Development, Rapid Appraisal of Agricultural Knowledge Systems etc) are the logical follow-up of the paradigm shift from the linear model to multiple-source models of innovation such as AKIS.

There are also some critiques of AKIS. Leeuwis (2004) finds that it looks at knowledge generation and use without considering the influence of political and other forces in the system and therefore cannot yield a complete and realistic analysis. Hall (2006) comments that the AKIS concept still focuses on research supply but gives more attention to links between research, education and extension and to identifying farmers' demand for new technology. Whether AKIS regards the formal research system as the only supplier of knowledge or whether it recognizes the capacity of other system actors to generate agricultural knowledge is an important issue that may help to draw a line between the NARS, the AKIS and the recently developed Agricultural Innovation Systems (AIS) perspectives. This issue, including other concepts that show the divide between and similarities of the different perspectives, is discussed later in this paper.

Agricultural Innovation Systems (AIS)

The innovation systems perspective has become increasingly important in explaining how innovation takes place and how and by whom benefits are gained out of complex technological and institutional change processes. The theoretical framework of innovation systems was first used to explain processes in the "developed" world, which are highly governed by the rules of a free market economy and more or less democratic governance systems. Industrial innovation is characterized by technology change in manufacturing, with emphasis on market opportunities and institutional changes. At industrial level, the oldest thinking about production was that: it happens as a result of the activities in the firm. In 1841, List brought the earliest description of "a national system of political economy", which is a precursor of the innovation systems concept. It assumes that production results not only from the activities of the firm but also from the social and economic institutions (education, infrastructure etc) that make production possible (Lundvall *et al* 2002, quoted in Spielman 2005). This created the basis for the rise of systems thinking in the industrial development arena. An innovation system can be 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 their behavior and performance. The innovation systems concept embraces not only the science suppliers but the totality and interaction of actors involved in innovation. It extends beyond the creation of knowledge to encompass the factors affecting demand for and use of knowledge in novel and useful ways (Hall 2006).

Lessons from applying the innovations systems perspective in the industrialized world have been used to conceptualize the Agricultural Innovation Systems (AIS) perspective. This has added value to the conventional, linear perspective on agricultural R&D, by providing a framework for analyzing complex relationships and innovative processes that occur among multiple agents, social and economic institutions, and endogenously determined technological and institutional opportunities (Spielman 2005). Given its industrial origin, current studies of AIS place much emphasis on the market and other institutional forces that affect innovation processes in agriculture.

Commercially important agricultural commodities that have greater value in national and global markets have attracted the attention of many authors working in developing countries. The analytical framework used by AIS is indeed helpful to study how innovation systems emerge, are coordinated and function, and how innovation performances are influenced by market and non-market forces in the context of market-led economic systems.

A broader characterization of innovation and innovation processes, viewed by some innovation system thinkers, has been summarized by Hall (2006) as follows:

- Innovations are new creations of social and economic significance. They may be brand new, but are more often combinations of existing elements.
- Innovation can compromise radical improvements but usually consists of many small improvements in a continuous process of upgrading.
- These improvements may be of a technical, managerial, institutional (that is, the way things are routinely done) or policy nature.
- Often, innovations involve a combination of technical, institutional and other changes.
- Innovation processes can be triggered in many ways, e.g. bottlenecks in production within a firm, changes in available technology, competitive conditions, international trade rules, domestic regulations and environmental health concerns.

KNOWLEDGE, INVENTION AND INNOVATION IN NARS, AKIS AND AIS

Some authors distinguish between invention and innovation. Often, “invention” refers to the first occurrence of an idea for a new product or process, while innovation is the first attempt to put the invention into practice. Invention is a new product, whereas innovation is a new value that brings benefits to improve human and environmental well-being. Drucker (1985) relates innovation with the market, saying that, if an innovation is product-oriented, it will create a "technology miracle" without creating the required benefits. Similarly, Baeon (quoted in Anandajayasekeram 2005) describes innovation as the economically successful use of invention, while invention is a solution to a problem. Bringing a “solution to a problem” in its broader sense is also a characteristic and purpose of innovation, but inventions provide only “knowledge solution” in a “restricted territory” and the narrowly defined context of the designers. Inventions may remain like miracle thoughts, practices or methods with limited application in the real world, if they are not transformed into innovations by entering into the complex relations and interactions of people and institutions in wider socio-economic, cultural and political contexts.

The NARS perspective does not make important distinctions between knowledge, invention and innovation. It is based on a belief that scientific research is the only supplier of knowledge and the types of knowledge created through the rigorous scientific process are new inventions, regarded as innovations. The process of generating new knowledge in the controlled environment of scientists is called an innovation process. Therefore, innovations are the products of scientific research work, of which the world is expected to make use. They are not products of social processes that take place as a result of the complex interaction of actors also outside the research system.

AKIS views innovation differently. It is not the desired outcome of a researcher or a group of researchers working in a controlled environment, in isolation from the bigger system, but rather the desired outcome of the knowledge system made up of multiple social actors with complex and interrelated missions and functions (Engel 1997). In contrast to Hall’s (2006) comments that AKIS focuses on research supply, the AKIS perspective does not see research as the sole supplier of knowledge, but as an important partner of other social actors engaged in generating and using knowledge. AKIS gives attention to the knowledge network in the system, recognizing the contribution of the actors in the network to creating the body of knowledge, bringing substantial

inputs for innovations to take place. The purpose of an AKIS is to facilitate continuous innovation in agriculture-related practices. The individual innovation performances of farmers, particularly the creative and new practices in farming and natural resource management (NRM), bring new socio-economic values to the users, and cannot be seen in isolation from the inputs of the other system actors. Röling (1996) describes innovation as a result of interaction among different actors making complementary contributions. Leeuwis (2004) shares this view and describes an innovation as a package of new social and technical arrangements and practices that implies a new form of coordination within a network of interrelated actors.

An important addition of the AIS to the AKIS perspective is the fact that AIS is concerned with a system made up of innovations that may take place at different knowledge fronts, such as the formal research system, the private sector, the technology delivery agencies, farmers and other social actors in the broader policy, cultural and institutional environment. This perspective is taken because of the significant influence of current world economic and social development, characterized by transformation in knowledge-generation processes from being elite controlled to a "knowledge society", from using papers to store and share knowledge to using digital media and the web, and from research as the key tool to generate knowledge to search and consultation (Hall 2006). In the AIS perspective, innovation management is given greater importance than knowledge management, which is an important aspect of AKIS.

In AIS, as in AKIS, the innovation process does not always starts with research and the knowledge coming from research does not necessarily create new practice or values. Rather, AIS underscores that it is only within the innovation system that knowledge and information from various sources interact to bring new phenomena desired by the system actors. Hall (2006) suggests that invention culminates in the supply (creation) of knowledge, but innovation encompasses the factors affecting demand for and use of knowledge in novel and useful ways. The notion of novelty is fundamental to invention, but the notion of creating local change, new to the user, is fundamental to innovation. Verkaik (1997, quoted in Leeuwis 2004) also suggests that, in the innovation process, knowledge and ideas need to be translated into skills and technologies and subsequently into real socio-technical innovation. Innovation is not just about research findings but the transformation of those findings into socially and economically valued products.

Table 1: Defining features of NARS, AKIS and AIS perspectives related to agricultural innovation systems

Defining feature	**NARS**	**AKIS**[a]	**AIS**
Purpose	Planning capacity for agricultural research, technology development and technology transfer	Strengthening communication and knowledge delivery services to people in the rural sector	Strengthening the capacity to innovate throughout the agricultural production and marketing system
Actors	National agricultural research organizations, agricultural universities or faculties of agriculture, extension services and farmers	National agricultural research organizations, agricultural universities or faculties of agriculture, extension services, farmers, NGOs and entrepreneurs in rural areas	Potentially all actors in the public and private sectors involved in creating, diffusing, adapting and using all types of knowledge relevant to agricultural production and marketing
Outcome	Technology invention and technology transfer	Technology adoption and innovation in agricultural production	Combinations of technical and institutional innovations throughout the production, marketing, policy research and enterprise domains
Organizing principle	Using science to create inventions	Accessing agricultural knowledge	New uses of knowledge for social and economic change

Mechanism for innovation	Transfer of technology	Interactive learning	Interactive learning
Degree of market integration	Nil	Low	High
Role of policy	Resource allocation, priority setting	Enabling framework	Integrated components and enabling framework
Nature of capacity strengthening	Infrastructure and human resource development	Strengthening communication between actors in rural areas	Strengthening interactions between actors; institutional development and change to support interaction, learning and innovation; creating an enabling environment

Source: as defined by FAO and World Bank (2002), adapted from Hall (2006).

Methodological reflections on AKIS and AIS

In the last two decades, the development and use of organized principles, procedures and tools to help study the relationship of the system actors in generating, disseminating and using agricultural knowledge was the focus area of AKIS. Different approaches are used to describe the AKIS at national level or the specific interactions that take place at sector level. The conventional survey method accompanied by interviews and focus-group discussions could also be used to describe the state of the art, but there are also well-thought through and carefully designed methodological approaches that go beyond describing the status of AKIS.

Rapid Appraisal of Agricultural Knowledge Systems (RAAKS) is a social research methodology that is useful to describe the status of AKIS and to facilitate agricultural innovation, by focusing on the social organization of innovation (Engel 1997). This methodology has three distinct phases. Phase 1 focuses on defining the problem situation with the concerned actors in an interactive way and identifying the diverse system actors that have important stakes in the innovation process. Phase 2 is a detailed study of the linkages and communication between the system actors, knowledge networks, coordination and the broader environment in which the innovation process is taking place. Phase 3 is a feedback session for the stakeholders to validate the findings and reach consensus on them, and to design joint action to enhance the innovation process, so as to overcome constraints caused by weak or lacking linkages and communication and limited sharing of knowledge and resources among the actors. The plan of action also benefits from the interaction and debate of the system actors during the course of the study and in the stakeholder workshop. A known problem situation that constrains innovation processes is taken as an entry point for a RAAKS exercise. The methodology is best used when diverse actors are involved in the action research and a well-trained facilitator is carefully handling the interactive process.

Participatory Technology Development (PTD) is another methodological approach that was that is based on the principles and assumptions of the AKIS perspective. It refers to joint experimentation and investigation by farmers and development agents and, wherever possible, formal researchers to discover ways of improving farmers' livelihoods. The focus is on developing technological innovations through equitable and active participation of farmers, extension workers and scientists. This methodology has tried to overcome the limitations of the NARS perspective, in which the research process – including agenda setting, data collection, analysis and reporting – is controlled and owned by the researchers and their peers in the formal sector.

As entry point, PTD takes agricultural problems often identified by farmers but also sometimes by researchers and other experts. The most challenging aspect of this exercise is the process of blending farmers' and outsiders' knowledge in a manner that they complement each other and bring new value relevant for local realities. This requires an attitude of respect and honesty among the participating actors. If scientists cannot recognize the initiatives of resource-poor farmers, if they

cannot appreciate the knowledge and reasoning behind the farmers' informal research and development efforts, if they cannot understand the social settings and motivations of the innovators, then they cannot be effective in engaging in research and development partnership with rural communities to alleviate poverty, increase food production and seek sustainable development (Waters-Bayer & Bayer 2005). The PTD framework has six phases: getting to know each other, looking for things to try, designing experiments jointly, trying things out (implementing joint experiments), sharing results and sustaining the process (Reijntjes *et al* 1992). Numerous other approaches such as Farmer Field Schools (FFS) and Farmer Participatory Research (FPR) share the same philosophy and principles of PTD, and can be grouped under the broad framework of PTD.

Participatory Innovation Development (PID) is a recently coined term to describe local innovation processes that take place with the support of outsiders. It broadly shares the philosophy and principles of PTD but has wider dimensions that PTD, which is more limited to the development of technology in the inner circle of farmers, researchers and extension workers. The unique feature of PID is that its entry point is not a known or defined problem situation but a local innovation, which emerges out of the creativity of the local people. The main purpose of PID is to enhance innovation processes that emanate from the local people, with the support of outsiders on technical, methodological, institutional and policy dimensions as well as making use of emerging opportunities relevant to the local innovation, such as market, policy, networks etc. The second important distinguishing feature of PID is that it deals with not only technical innovation, but also institutional, market, organizational, management, cultural and other forms of social innovation. PID uses the broader framework of PTD; a modified framework that helps accommodate the new values and dimensions of PID has yet to emerge.

The AIS perspective focuses on the dynamics of innovation processes, departing from important aspects such as knowledge, institutional changes, market forces and policy environment. The methodological approaches are new and still being tested, and some new methods and tools are still required. The AIS perspective may use any social science research methodology such as qualitative studies as well as descriptive methods to analyze and describe the innovation systems at national level. The challenge is how to use the AIS perspective to facilitate innovation performances at sector level or in a given domain of human activity. One limitation is that no specific and well-thought through methodologies and tools are available to help design or facilitate innovation from the AIS perspective. More often than not, studies are simply *ex post* descriptions of the dynamics and complexities of some technological or institutional innovations – and there the analysis ends (Spielman 2005). In the same text, Spielman also suggests the possibility of using a variety of methodological approaches in the AIS, including:

- Analysis of the costs and benefits of knowledge production or dissemination, given the complexity of interactions among diverse agents
- Methodologies used in studying social learning processes among agrarian agents
- Benchmark or best-practice method, which was used by the OECD to study innovation systems in industrialized countries
- Game theory models that help break down interactions into key decision points and payoffs (more applicable for knowledge-intensive sectors)
- Agricultural Technology Management System (ATMS) analysis, which attempts to analyze interrelationships within and between organizations and between organizations and external environments to improve organizational design and management functions.

Hall (2006) has described the basic hypothesis of the methodological framework for AIS as follows: the capacity for continuous innovation is a function of linkages, working practices and policies that promote knowledge flow and learning among all actors within the sector. The methodology is not, however, interested only in identifying the links or missing links in the system

but seeks to go beyond that and unpack the relationship further to analyze the underplaying causes and its impacts on the system. Hall has broadly identified four major focus areas: sector timeline and evolution, sector mapping, attitude and practice of organizations, and wider policy and support structure in the methodology.

LESSONS DRAWN FROM COMPARISON

AIS

The following table is taken from the study conducted by Hall (2006) to assess the relevance of the AIS approach. The study aimed to provide comprehensive conceptual and methodological feedback on issues concerning AIS. Several authors were involved in the country case studies, but the full papers of these studies are not annexed to the main report. Because the reflections below are based only on the summary of findings that Hall presented in the main report, we cannot claim that the analysis and conclusions in this paper are fully informed by the country case studies. The analytical issues presented in Table 2 are important to reflect on the adequacy of the AIS perspective to study innovation in grassroots systems of sub-Saharan Africa.

Table 2: Major findings of the AIS study in five sectors (Hall 2006)

Countries included in the studies	**Sector focus**	**Issues addressed**				
		Innovation	**Environment**	**Market**	**Empowerment**	**Sustainability**
Bangladesh	Commercial shrimp industry, dominated by export companies	- Industry lacks confidence in research; interaction with it is weak - Ability of poor to innovate undermined - Reactive approach to problem solving	Environmental polices not enforced because of government negligence	Market relations well developed	Social equity need to be addressed	Progress required in creation of efficient sector coordination body
Bangladesh	Home-based small-scale food processing sector that accounts for 80% of total industry	- Isolated and little access to information made it difficult to meet consumer preference and quality standards - Weak tradition of public research on food processing - NGOs provide training on food processing - Sector lacked credit and technical skills to meet hygienic standards	Not addressed	Many rural areas remain physically isolated from the main urban market in Dhaka	Not addressed	Not addressed, recommenda-tion focuses on capacity development
India	Exportable medicinal plants, growing in response to international demands	- Large pharmaceu-tical companies developed associated research - Small family-owned businesses lack research support - Long-established mistrust among public research	Environmental degradation from the destructive harvesting of plants	Sell tradi-tional herbal medicine at local market Large phar-maceutical industries strongly linked with international	Not addressed	Not addressed

		organizations, private sector and NGOs - Resistance to hybridize scientific and traditional medicine		market		
Ghana	Pineapple export industry	- Developed own individual experts and research or relied on foreign advisors - Public research played minor role in developing pine-apple export market - Assumption that scientists' work is commercially irrelevant, does not address topics significant to sector - Universities are disconnected from the sector	Not addressed	- Private sector efficient in multiplying and distributing planting materials - Export market is continually growing, despite growing competition and changing preferences of consumers	Inclusion of small producers recommended	Not addressed, focus of the recommenda-tion is on improving capacity and coordination
Colombia	Growing cassava-processing agro-industry	- Latin American consortium for cassava R&D and regional consortium of producer countries have very strong linkages to national and international research organizations, including small-scale farmers - Apex organizations link with processing and marketing innovations	Not addressed	- In 1990 structural adjustment pulled the attention of policymakers to cassava - Mid-90s government renewed interest - The industry has strong links to domestic and international market	Not addressed	Not addressed, recommenda-tion focuses on market research and technological innovation and more investment from government

The issue of ***innovation*** was addressed in Hall's study from the viewpoint of the institutional linkages that do or do not support innovation processes, most notably, the functional linkages of the commercial sector and the public research institutions. The study shows the importance of the private sector in the innovation process as a source of innovation performances, either from its own research system or through hiring high-level professionals. However, the type of core innovation performances (new technical, institutional or other social innovations) that determine the level of complexity of the innovation systems are not spelled out well. The role of smallholder farmers in the innovation process is addressed only in the Bangladesh shrimp-industry case, where the ability of the poor to innovate is reportedly undermined. This indicates that the framework – specifically the terms of reference for the study, which is based on the AIS framework – does not consider farmers' innovative capacity to be an important pillar of the AIS that deserves closer examination. In grassroots innovation systems perspective, in contrast, the role of individual or groups of farmers in innovating or in stimulating innovation processes is very important.

Human actions in innovation can have an impact on the ***environment***, sometimes undesirable. It is imperative to understand the relationship of human action and environmental impacts and try to reverse, also prevent, those impacts whenever possible. In some of the case studies, human actions had a very direct impact on the environment, e.g. the lack of policy enforcement in the shrimp industry in Bangladesh, and the risk of destroying the natural herbs when seeking medicinal plants. However, no information is given about the impacts of the other sectors on the environment, although there would certainly be some impacts to report. The degree of emphasis might depend on the professional interest of the people involved in the country case studies, but it is also important to ask if the AIS conceptual and methodological framework is adequate for looking into the relationship between innovations and the environment. Innovation is not a technology but a value that can be measured by environmental impacts (Drucker 1985).

The study gives attention to the private sector and associated ***market*** issues and shows how market forces – not only the demand and supply relations but also marketing infrastructure and other facilities – can make or break innovation performances. All case studies gave attention to how market relations developed at local and international level, and the role played by governments to improve the market. Market issues obviously receive adequate attention in the AIS conceptual and methodological framework, and in the terms of reference for the country case studies.

The concepts of ***empowerment*** and ***sustainability*** are closely related, as one may benefit the other, but can also have negative impacts on each other, if the relationship goes wrong. We refer here to empowerment relevant to grassroots innovation systems in sub-Saharan Africa and elsewhere in the developing world, i.e. the opportunity, capacity and ability of the end-users to access, develop and use information and knowledge, to make decisions on R&D priorities, and to influence the decisions and practices of others whose policies and practices affect the farmers' lives of the community and the resilience of the system to respond to challenges exerted by human and non-human forces. Sustainability in connection to innovation performances refers to the extent that the innovation is informed by local knowledge and environmentally friendly, the cost and availability of technologies or services used to create new values, and the marketability and suitability of the innovation performance to the local sociocultural context. In connection to grassroots innovation systems, where influence of market is relatively low, the issues of empowerment, sustainability and environment are particularly important. The further from urban, industrialized settings and the closer to the rural economy of the developing world, the stronger is the link of the people with the environment, as the majority makes a living out of the natural resources. Moreover, the social capital in the grassroots systems of developing countries greatly influences innovation and development affairs.

In the study by Hall (2006), however, the issues of community empowerment and *sustainability* are not central, although some comments were made as recommendations, such as inclusion of small-scale producers in the pineapple industry of Ghana and the need for social equity in the shrimp industry of Bangladesh. Hence we raise the question once again: how much does the conceptual framework of AIS consider the issues of sustainability and empowerment as determinants of innovation performances? The framework appears to be most attracted to the commercial sector, where the issue of market is more important than social capital and related issues.

AKIS

Rivera *et al* (2005) assessed the status of AKIS in ten developing countries according to five parameters: 1) policy environment; 2) institutional structure for supporting innovation; 3) conditions for expressing demand for innovation; 4) partnership and networking; and 5) finance systems for innovation. The results are indicated by marking crosses (0–3) to rank the magnitude of each parameter in the respective countries. The greater the number of crosses, the stronger the performance is.

Table 3: Status of AKIS in ten countries (from Rivera *et al* 2005)

AKIS parameters	Cameroon	Chile	Cuba	Egypt	Lithuania	Malaysia	Morocco	Pakistan	Trinidad & Tobago	Uganda
1. Policy environment										
Existence of national AKIS policy, plan formal agreement	xxx	xxx	xxx	x	xxx	xxx	xxx	xxx	x	xxx
AKIS targets public goods	xxx	xxx	xxx		xxx	x	x			x
Attention to economic efficiency of agricultural sectors	xx	xxx	x		xx	xx	x			x
2. Institutional structure for supporting innovation										
Existence of AKIS units	xx	xxx	xxx	xxx	xx	xxx	xx	x		xxx
Central and branch supervision	xxx	x	x			xxx	xx	x	x	x
Initiatives to build institutional resources	xx		xxx		x	xxx	xx	x	xx	xxx
Sound strategy for program decentralization / subsidiarity	xx	xxx	xx		xx	x	xx	x	x	xxx
Monitoring, evaluation and impact assessment	xxx					xx	x	x		
Functional performance of AKIS entities	xx	xx	x	x	xx	xx				
3 Conditions for expressing demand for innovation										
Demand-driven orientation	x	xxx	x		xx		xx			xxx
Agricultural market support		xx			xx	xxx			x	xx
Input (credit supplies) support	xx	x			x	x				
Physical infrastructure support	x	xx	xxx	xxx	xx	xx	xxx			xx
Joint planning/effective linkages	x	x	xx	x		x	x			x
Education for agricultural producers (APs)	x	X	xx	x	x	x	x	x		xx
Gender inclusion	xx		x	x		x	x			
4. Partnership and networking										
Structures for institutional cooperation	xx	xx	xx	x	x	xx	x	x		xx
Existence of strong public-private partnership (pluralism)	xx	xxx			x	xxx	x		x	xx
Program participation by APs	x	xxx	xx		xxx	x	xx			xx
Effective use of traditional communication	x					x			x	x
Effective use of modern / computer internet technology		xx	xx	xx	xx	xx				x
5. Financing systems for innovation	xx	xxx	xx	x		xxx				x
Adequate funding for AKIS	x	xxx			xx	xx	x			xx
Repartition of costs	x	xx	xxx		xx	x	xx			xx
Investment to develop stakeholder capacity										

This study pays particular attention to how public institutions – namely, of research, extension and education – are aligned to develop public goods. In the AKIS case studies, the role of the public institutions in the innovation process is seen as very high and the private sector is not addressed as a source of innovation. In contrast, the role of public research in supporting the private sector in the AIS studies is very low, maybe because the emergent property of the system from the AIS perspective is commercial, rather than public goods. The AKIS studies do give some attention to market issues, such as agricultural market support, input support (including credits) and infrastructural support. However, had the private sector been seen as a source of innovation, the linkage framework for AKIS would not have been triangular (research, extension and education) but rectangular, including also the private sector. Although the conceptual and methodological frameworks for AKIS (PTD/PID) discussed earlier do recognize and appreciate the potential of smallholder farmers to innovate, the case studies did not address those issues at all. The fact that the study was conducted at country level should not prevent the framework to comment on the role played by farmers in innovation. The national picture must be able to reflect the dynamism of AKIS on the ground.

A point mentioned in the AKIS study and not in the AIS case study concerns financing innovation, referring to public, public-private and cooperative funding for research. Funds are made available through competitive grants to enhance innovation. Concurrent to the limited attention in the AKIS study to local innovation and the capacity of the local people to innovate, no resources were made available in any of the country cases for financing innovation at the grassroots level, nor did the authors comment on this.

COMPLEMENTARITIES AND DIFFERENCES

Major complementarities

Both perspectives are grounded in the systems thinking of the constructivist paradigm. The AIS and AKIS frameworks are complementary, but each also has its own strengths and limitations when used to study innovation in grassroots systems. Unlike the NARS perspective, in both AKIS and AIS, innovation is a social phenomenon that takes place in the complex interaction of diverse social actors rather than in the isolated and controlled environment of researchers. Both recognize scientific knowledge coming from research organizations and other sources as an important, but not the only, input for innovation to happen. AKIS and AIS share the principle that there are multiple sources of innovation in agricultural innovation, and both – in principle – recognize the innovative capacity of farmers. But the specific case studies reviewed for this paper suggests that neither of them give much attention to recognizing and developing farmers' capacity to innovate. The problem may lie more in the methodological limitations of the studies than in the principles and assumptions of the theories. For example, the PID approach, which focuses on the innovation capacity of local people, was essentially developed on the basis of the AKIS perspective but also shares many values and principles with AIS, in the sense that it seeks diversified types of innovation rather than being limited to technological ones.

Major differences

The major difference between the two perspectives is in emphasis and in choices of areas of interest rather than in the basic philosophies and principles. However, these differences have implications for policy formulation, direction and consequent institutional changes. Therefore, the differences cannot be ignored; rather, elucidating them will be help to identify possible areas of methodological synergies to explain innovation systems that have a mix of the interest areas of AIS and AKIS.

As mentioned above, public institutions play a strong role in the innovation process from the AKIS perspective but not from the AIS perspective. AKIS focuses on the linkages between the main public institutions relevant for agricultural innovation, while AIS addresses a wider set of social actors including the private sector and NGOs. In terms of technological innovation, in the AIS case studies the private sector takes the lead, through building own capacities and buying services from elsewhere. It depends very little on public research institutions for knowledge. Commercially important agricultural commodities with high value in national and global markets have obviously attracted the attention of the authors. Therefore, the question is about making choices between developing commercial goods (in which AIS is most interested) and targeting public goods, which AKIS often does. The questions regarding policy choices may be:

a) Should countries have a private-sector-led development policy, where the macro-economic and investment policies favor the creation and development of the private sector, with a corresponding diminishing role of the public institutions?
b) Should they have a strong public sector fostering production of necessary goods and services to the people, possibly narrowing the chance for the private sector to develop?
c) Should they have a combination of both?

The choices would depend on the socio-economic level, governance system and political ideologies of the countries. In the AKIS study, Rivera *et al* (2005) commented that the private sector can play an increasingly important role in rural knowledge systems, but total privatization is not possible, even for commercial agriculture. The appropriate mix of public and private roles can best be determined through piloting and learning from experience. On the other hand, AIS thinkers (e.g. Drucker 1985) focus on the creation of marketable value. New economic value should be the desired outcome of the innovation system. Therefore, from the two case studies, the main lesson that could be drawn is: choices for AKIS or AIS frameworks to study the national or sector-level innovation systems depend on the policy choices of the governments for development.

Unlike AIS, AKIS gives much emphasis to facilitating innovation and not just describing the process of how innovations happen and why. This is an obvious advantage of AKIS over AIS, as the approach helps to design and enhance innovation processes. RAAKS, PTD and PID are all instrumental to facilitate innovation. Some AIS authors have recognized the limitations of the AIS perspective with regard to not being able to come up with methodologies to facilitate innovation. Hall (2006), while drawing key insights from the case studies conducted on AIS, mentioned that "innovation can be based on different kinds of knowledge possessed by different actors: local, context-specific knowledge (which farmers and other users of technology typically possess) and generic knowledge (which scientists and other producers of technology possess). In an ideal

innovation system, a two-way flow of information exists between these sources, but in reality this flow is often constrained because information is embodied in different actors who are not networked or coordinated. A central challenge in designing innovation systems is to overcome this asymmetry – in other words, to discover how to bring those possessing locally-specific knowledge (farmers and entrepreneurs) closer to those possessing generic knowledge (researchers or actors with access to large-scale product development, market placement or financing technologies)."

Because AKIS emerged to overcome the limitations of the NARS perspective on technology development, it is preoccupied with issues of how technologies are developed in a different way than in NARS. This history has kept AKIS focused on technological innovation, to which the major issues addressed by AKIS, such as knowledge and institutional change, are strongly related. In contrast, at least in theory, AIS encompasses technological, market-related, financial, institutional and other forms of social innovation. The PID approach, which grew out of the AKIS perspective, puts much the same emphasis as AIS does on addressing more than only technological innovation, but much methodological and empirical work is still necessary to put this theory into practice.

CONCLUSIONS

Because its history is rooted in the industrial innovation systems thinking, AIS is more attracted to commercial sectors, where market aspects are more important than social capital and related aspects. The AIS case studies were carefully selected. They are either commercially well developed and employ numerous people, sometimes with particular emphasis on smallholder commercial agriculture, or a quickly growing sector that is seizing market opportunities at local and national level. The selection criteria for the sectors confirm that the target group that AIS addresses is not necessarily "farmers" but all people who are involved in farming, processing, packing, trading/entrepreneurship, financial activities, brokering etc. In contrast, farmers are right in the centre of the AKIS perspective, and the institutions that AKIS is dealing with, such as the public research, extension and education organizations in developing countries, are traditionally concerned with the issues of farmers. The case study on AIS shows that public research organizations gave little or no support to most of the sectors considered in the study. The emphasis of AKIS is not on commercial organizations but on small-scale farmers, who have greater connection with the natural resources such as soil, water, forest, animals and biodiversity in general. In most cases, the farmers in developing countries are managing common resources such as land, water, forest etc. Issues of sustainability and community empowerment are very important where common resource management, poverty and environmental aspects are strongly connected. This leads us to conclude that the AKIS perspective is more relevant for grassroots innovation systems in sub-Saharan Africa.

It must, however, be noted that – in food-insecure parts of sub-Saharan Africa – the issue of market has often been considered as a second-generation problem. Therefore, the state and non-state actors concerned with food production have paid little attention to market issues. Meanwhile, it has become evident that the global changes in market regulations and government policies on market liberalization and decentralization of power will

require changes in the conception and practices of innovation processes. Therefore, the addition of AIS on AKIS – especially its emphasis to market forces and more diversified actors and target groups (for study purposes) – is very important. This suggests that the greater emphasis of AKIS on farmers, NRM and related sustainability and community-empowerment issues should be supplemented with important concepts in AIS about the multiple sources of innovation and the different types of innovations (technical, institutional, social etc). PID could, in principle, accommodate the basic concepts of both AKIS and AIS, but the approach would need further improvement to accommodate the new additions of AIS (private sector, NGOs, market and institutional analysis).

Both the AIS and AKIS perspectives still need to answer the question: should agricultural innovation performances be measured just by their technical and institutional capabilities to yield economic benefits, or should they also be assessed from the standpoint of local and global environmental concerns, which also entail elements of sustainability and empowerment of the resource users? The environment in the grassroots innovation systems of sub-Saharan Africa is under great danger, because of the desperate needs of the intervening actors to achieve food security, sometimes at the expense of the environment. Empirical studies that may show the relationship and interdependency of the innovation elements, including the technical competencies, economic benefits and environmental friendliness (both natural and social), may help to answer this question.

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