African Journal of Biotechnology Vol. 7 (11), pp. 1604-1611, 3 June, 2008
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB08.289
ISSN 1684–5315 © 2008 Academic Journals

Review

Innovation system approach to agricultural development: Policy implications for agricultural extension delivery in Nigeria

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Accepted 14 May, 2008

A sustainable and dynamic approach to agricultural development has remained of great concern to the government and priority for discourse in the policy arena. Past efforts have concentrated on investment in research and development which was established on the consensus that the application of science and technology is responsible for the structural transformation required to propel the agricultural sector. Public research and extension institutions are projected as the sole source of innovation/knowledge requisite to trigger development in the agricultural sector. Several other relevant macro economic and meso level factors such as policy and legislative framework and nature of human capital, physical infrastructure, finance and investment climate and system for facilitating information and knowledge flows were not considered as important. The emerging reforms and changes in knowledge structure of agriculture explicitly indicate that the traditional agricultural research and extension system alone cannot sufficiently address the challenges of the new trends. Innovation system approach offers a holistic and, multi-disciplinary approach to innovation and processes, incorporating emerging reforms and approaches for agricultural development. This paper concludes that government, policy makers, and administrators should invest and promote researches in sectors/sub sectors of economic and food security importance, using this analytical framework. Government should encourage and facilitate farmer and private sector innovative strength by enacting favourable polices (patenting and reward system) that will act as incentives. Institutional context of any innovation should be sufficiently analyzed by policy makers as requisite to promoting such innovation, while extension workers should build such information in technology packages to farmers.

Key words: Agricultural innovation system, research, extension, linkages, farmers.

INTRODUCTION

The fundamental condition for overall social and economic growth of many developing countries is a dynamic agricultural sector brought about by a steady increase in agricultural productivity. Reports on agricultural production and food security showed that food production has to increase substantially to meet the food demand of growing population (Wikipedia, 1995; Amalu, 1998). Unfortunately, over the years, the performance of the agricultural sector continues to be relatively disappointing. In developing countries, growth has been increasingly on the decline.

In the past, scientists have blamed the above scenarios on the non-adoption of new agricultural technologies by rural farmers. Some scientists argued that if African farmers with limited resources had adopted some of the technological innovations generated by research over the past decades, declining food security and increasing poverty would not be major crisis today. Arokoyo (1998) however opined that for a variety of reasons, the performance and output of national agricultural research and extension system in West and Central Africa has not been commensurate with the size, scope and level of investment in the system, as evidenced by farmers' poor

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productivity, incessant and intractable food shortage and the accompanying high food prices. More recently, the low performance of the agricultural sector is rather viewed as a system problem, which is prevalent within the research – extension – farmer – input system.

Traditionally agricultural research system in Nigeria is characterized by a top-down, centralized, monolithic and isolated structures. Linkages, interactions and learning mechanisms among the component actors are notably weak and/or often non-existent. Empirical evidence revealed several linkage gaps and missing links among and between the actors in the system (Agbamu, 2000; Uzuegbunam, 2001). Institutions, for example, universities and research institutes innovate in isolation and although research were taking place at various national and international organizations, the coordination is dysfunctional, and poorly linked to the productive sector. Besides, farmer innovations were not being included in the knowledge system. The emergence of Research Extension Farmer Input System (REFILS) management mechanism has not significantly changed the situation. Reports indicated that REFILS approach to linkage problems initiated by World Bank has only strengthened the traditional weak linkages between research and extension, and linkages among research institutes, but farmers and government are weakly linked (Arokoyo 1998; Asiabaka, 2007). It was further reported that private sectors involvement are discouragingly weak. The micro innovative strength therefore has remained isolated and encapsulated and many institutions relevant to innovations are weak and possibly non-existent. Undoubtedly the participation of NGOs in research and extension has largely increased but their linkages and interactions are generally weak. Hence adopting an interactive, more inclusive and dynamic analytical framework to improve networking and the quality of technological linkages and knowledge flow is an imperative.

It is important to note that investment in knowledge especially in the form of science and technology has featured prominently and consistently in most strategies to promote agricultural development at the national level. Generally, the argument is that without adequate investment in science and technology, economic growth will remain a mirage. Moreover, technological change rather than institutional context is believed to drive social and economic development. Admittedly investment in science and technology may increase knowledge, but may not spur innovation culture in the whole system. Institutions and other macro economic and meso level factors including the policy and legislative framework and nature of human capital, physical infrastructure, finance and investment climate and systems for facilitating information and knowledge flows among the various actors and institutions should be sufficiently addressed. Thus a more comprehensive approach to analyzing the technological development and processes is timely. Above all, current trend and changes in agricultural research and development processes (such as demand-driven and participatory research), policy reforms (privatization, cost-sharing, decentralization, liberalization of market and others), and context of agriculture come with formidable challenges.

The above scenarios point to the need for a relatively new paradigm that incorporates these reforms. Innovation system approach offers a more holistic, multidisciplinary and comprehensive framework for analyzing innovation process, the roles of science and technology actors and their interactions, emphazing on wider stakeholder participation, linkages and institutional context of innovation and processes. This paper therefore was aimed to:

1. review the concept of innovation system;
2. appraise the application to agriculture and its relevance and
3. analyze the policy implications for agricultural extension delivery in Nigeria.

CONCEPT OF INNOVATION SYSTEM

Innovation system approach emerged in the mid 1980s as a Schumepeterian perspective that drew significantly from the literature on evolutionary economics and system theory (Speilman, 2005). However, more comprehensive description was first set forth by Lundvall (1985) and applied to national comparisons of innovation system by Freeman (1987 and 1995), Nelson (1988 and 1993) and Edquist (1997) with empirical application focusing primarily on national industrial policy in Europe, Japan and several East Asia countries that were experiencing rapid industrialization during the 1980s. Metcalfe (1995) and Roseboom (2004) further confirmed that the concept of innovation system was first mentioned in the industrial literature in the late 1980s and later entered into the vocabulary of national and international policy markers in the industrialized world. In recent times the concept is gradually spilling into policy making circles in developing countries.

Innovation system thinking represents a significant change from the conventional linear approach to research and development. It provides analytical framework that explore complex relationships among heterogeneous agents, social and economic institutions, and endogenously determined technological and institutional opportunities. It demonstrates the importance of studying innovation as a process in which knowledge is accumulated and applied by heterogeneous agents, through complex interactions that are conditioned by social and economic institutions. According to Tugrul and Ajit (2002) it is not a simple aggregation of organizations as portrayed by some views, but a group of agents who

operate like an invisible ochestra characterized by coherence, harmony and synergy. It is an interactive learning process in which enterprises/agents in interactions with each other, supported by organizations and institutions play key roles in bringing new products, new processes and new forms of organizations into social and economic use (Francis, 2006). The above definitions point to the three essential elements of innovation system namely:

1. The organizations and individuals involved in generating, diffusing, adapting and using knowledge.
2. The interactive learning that occurs when organizations engage in generating, diffusing, adapting and using new knowledge and the way in which this leads to innovation (new products, processes or services).
3. The institutions (rules, norms, conventions, regulations, traditions) that govern how these interactions and processes occur.

The concept of innovation system is built on several assumptions and integrates current trends in development in the analytical framework. They include the followings:

a. Innovation takes place everywhere in the society and therefore bringing the diffuse element of a knowledge system and connecting them around common goals should promote economic development.
b. Innovation is an interactive process and is embedded in the prevailing economic structure and this determines what is to be learnt and where innovation is going to take place.
c. Innovation includes development, adaptation, imitation and the subsequent adoption of technology or application of new knowledge.
d. Innovation takes place where there is continuous learning and opportunity to learn is a function of the intensity of interactions among agents.
e. Heterogeneous agents are involved in innovation process, and formal research is a part of the whole innovation processes.
f. Linkages and/or interaction among components of the system (knowledge generating, transfer and using agents) are as important as direct investment in R and D.
g. Institutional context rather than technological change drives socio-economic development.
h. In addition to technical change and novelty, innovation includes institutional, organizational and managerial knowledge.

Speilmen (2005) reported that analysis of innovation system may focus on the study of the system at different spatial (local, regional, national) at different sectoral levels (agriculture, pharmacy) in relation to a given technological set (biotechnology, ICTs), focus on the material (particular goods or services) and temporary dimension that studies how relationships among agents change over time as result of knowledge flow.

Analytical dimension at national level is referred to as national innovation system. It is that set of distinct, institutions which jointly and individually contributes to the development and diffusion of new technologies and which provides the framework within which government forms and implements policies to influence the innovation process. Metcalfe (1995) defined it as a system of interconnected institutions to create, store and transfer the knowledge, skills and artifacts which define new technologies. The element of nationality, according to Metcalfe (1995) follows not only from the domain of technology policy but from elements of shared language and culture which bind the system together, and form the focus of other policies, laws and regulations that condition the innovative environment.

Characteristics of national innovation system

Generally the characteristics of most national innovation systems are:

(1) They try to break out of the traditional linear and supply-driven thinking of research, technology transfer and application and emphasizes on interdependence and non- linearity in innovation processes and on demand as a determinant of innovation.
(2) They are strongly influenced by evolutionary thinking. Innovation processes and systems are context specific and strongly influenced by each country's economic and sociological experiences.
(3) They place great emphasis on the role of institutions, in terms of norms, rules, laws and organizations.
(4) They place emphasis on the patterns and intensity of interaction between the different actors within the national innovation system.
(5) Innovation system is seen as an analytical tool that can be used for policymaking and planning. It is not a blue print of how innovations should be organized (Roseboom 2004).

APPLICATION OF INNOVATION SYSTEM CONCEPT TO AGRICULTURE AND ITS RELEVANCE

In the last decade, economic and technology strategies have shifted from national agricultural research system (NARS) to agricultural knowledge, and information system, (AKIS) and more recently to agricultural innovation system (AIS). The national agricultural research system perspective emerged in the late 1980s and tends towards linearity in movement of knowledge from known source (formal research) and flowing to some end users (the

farmers). It further recognizes the public good nature of agricultural research, the role of the state in fostering technology change, and assumed that the social and economic context of technological change is exogenous and unchanging. By 1990s agricultural knowledge and information system (AKIS) evolved as a more sophisticated and less linear approach. Contrary to the focus of the NARS, it emphasizes linkages between research, education and extension in generating and fostering technological change. AKIS, however, is limited in its ability to conduct analysis beyond the nexus of the public sector and to consider the heterogeneity among agents, the institutional context that conditions their behaviours and the learning processes that determine their capacity to change (Speilman, 2005). In general, the system projects agricultural research system as the epicentre of innovation as opposed to the multiple knowledge base put forward in innovation system perspective. The agricultural innovation system (AIS) comprises a far broader set of actors than the traditional agricultural research, extension, and education agencies. Innovation takes place throughout the whole economy, and not all innovations have their origin in formal S and T nor are they all exclusively technical. This new perspective places more emphasis on the role of farmers, input suppliers, transporters, processors and markets in the innovation process. While each of the three system concepts has its own strengths and weaknesses, they can be seen as interlinked and cumulative: NARS focuses on the generation of knowledge, AKIS on the generation and diffusion of knowledge, and AIS on the generation, diffusion, and application of knowledge.

Agricultural innovation system evolved directly from the concept of national innovation system with the sectoral level as the unit of analysis. Adapting the various definitions of innovation system, agricultural innovation system is defined as a set of agents that jointly and/or individually contribute to the development, diffusion and use of agriculture-related new technologies and that directly and/or indirectly influence the process of technological change in agriculture (Tugrul and Ajit, 2002). The organizations include research institutes, training and education institutions, credit institutions, policy and regulatory bodies, private consultants/NGOs, farmers, farmers' associations and public services delivery organizations. It emphasizes agricultural innovations and goes beyond previous know-ledge system concepts by incorporating the goals of current reform measures, such as political decentralization, public sector alliances with the private sector, enabling private sector participation in advancing consensus approach to development and promoting demand-driven services. Besides, it captures the intricate relationships between diverse actors, processes of institutional learning and change, market and non-market institutions, public policy, poverty reduction and socio-economic development. Figure 1 shows the possible linkages and relationships among diverse actors in an agricultural innovation system.

By adopting an AIS perspective, bigger issues come into focus than when adopting a more limited NARS or AKIS concept. By starting at the knowledge-application end, the question of why farmers innovate or why they don't becomes a major issue for debate and research. What are the constraints that hold them back? Is it the prices in the market, for example, or the lack of (or lack of access to) technology? Are farmers passive recipients of technology or do they actively search for innovations? What are the roles of input suppliers, cooperatives, traders, processors, NGOs, and government-extension services in technology diffusion? What are the relative strengths and weaknesses of each diffusion channel? How can they be improved and what can be done to reach more farmers? In answering these questions, we may learn that the most critical bottleneck is not the lack of available technology, but whatever prevents other factors from playing their often-far-more-crucial role.

Hall and Yoganand (2002) highlighted that applying innovation system to agriculture in developing countries may provide the following features:

a. It focuses on innovation as its organizing principles. Here the concept of innovation is used in its broad sense as the activities and processes associated with the generation, production, distribution, adaptation and use of new technical, institutional, organizational and managerial knowledge.
b. Conceptualizes research as part of the wider process of innovation and extends its tentacle to identify actors and their scope, and the wide set of relationships in which research is embedded.
c. Recognize the importance of both technology producers and technology users and acknowledge that their roles are both context specific and dynamic.
d. It recognizes that the institutional context of the organizations involved (and particularly the wider environment that governs the nature of relationships) promotes dominant interests and determines the outcome of the system as a whole.
e. It recognizes that innovation systems are social systems. It therefore focuses not only on the degree of connectivity between different elements but also on the learning and adaptive process that make systems dynamic and evolutionary.
f. Matches better with the non-linear interactive concept of innovation.
g. It is more holistic including the final step (application) in the innovation process and incorporate ideas from various disciplines.
h. It stresses the importance of linkages among different actors.
i. It is only a framework for analysis and planning and can draw on a large body of existing tools

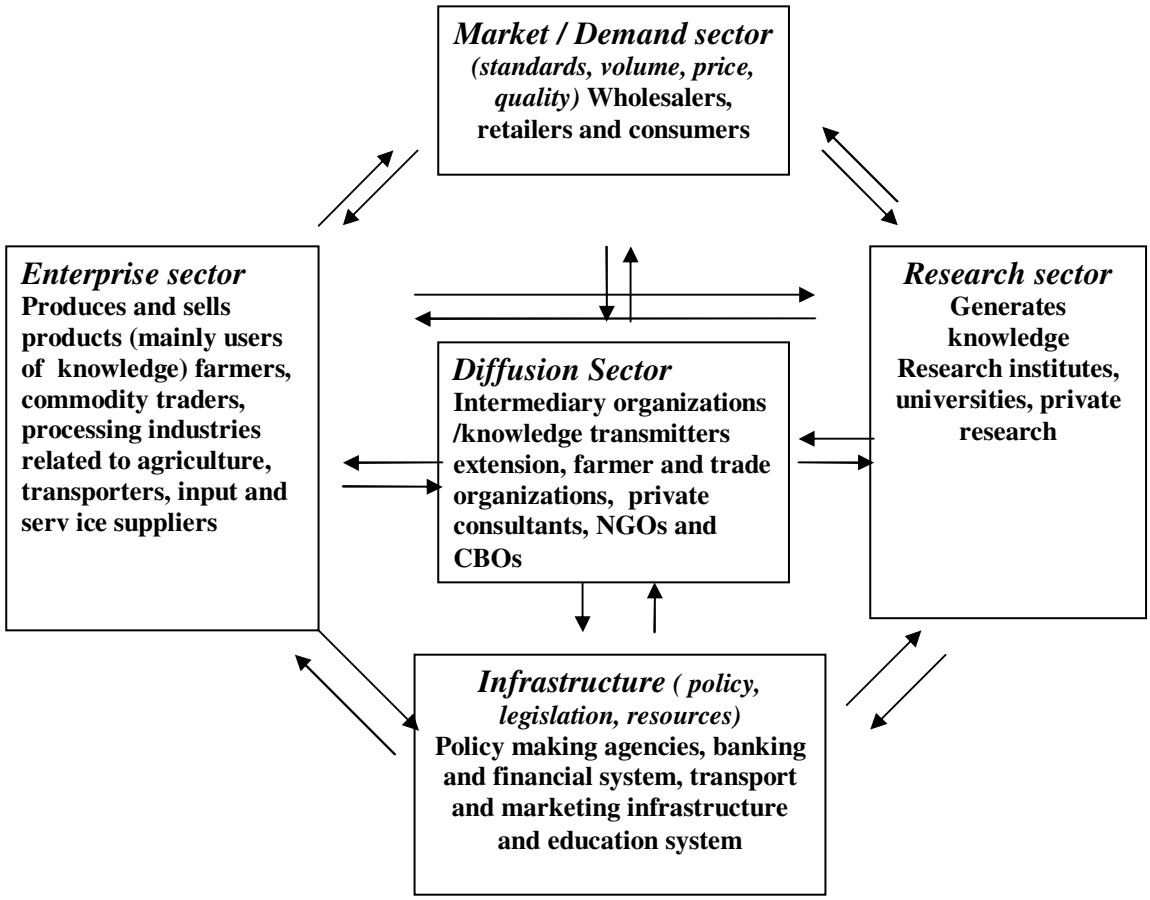

Figure 1. Possible actors in the agricultural innovation system. Adapted from CABI/CTA/KIT/VRLIE/WUR (2006).

(CABI/CTA/KIT/VRLIE/WUR, 2006).

Nonetheless, scholars have expressed concern as to the relevance of national innovation system concept for agriculture in developing countries. Issues raised include the fact that transplanting the insight from innovation studies in developed countries is against the evolutionary character of the national innovation system, which argues that innovation process and systems are context specific and historically determined. In contrast however, Johnson and Segura-Bonilla (2001) reporting from their experience in Central America favourably argues for the suitability of national innovation system for agriculture in developing countries buttressing the following points:

1. The national innovation system conceptual glasses help to concentrate on what we believe is important in development as it takes departure in learning capabilities and focuses on innovation processes and their role in development.
2. It has a broad explanation of innovation as based on both research and in every day routine economic activities and in both high-tech and low-tech sectors.
3. Its growth factors are interacting and feeding upon each other. An interaction between firms, organizations and the public sector is the essence of the concept.
4. Institutions and production structures matter.
5. It is a flexible approach, which for example can direct emphasis on local, national, regional systems and their mutual interdependence.
6. Finally, it is an inherently comparative approach and compares the anatomy and changes of different innovation systems.

In addition, Speilman (2005) argued that innovation system perspective on agriculture is critical to shifting socio-economic research beyond technological change “induced” by the relative prices of land, labour and other production factors in agriculture; beyond the concept of linear technology transfers from industrialized to developing countries, from advanced and international research centres to national systems as engine of change.

Emperically, the application of the innovation system approach at different analytical dimensions such as local, national, regional, sectoral and others have been advanc-

ed in literature. For instance, its early application started with introducing the concepts such as institutional learning and change, and the relationships between innovation and institutional context in which innovations occur. According to Speilmen (2005), studies by Johnson and Segura Bonilla (2001), Clark et al. (2003) Arocena and Sutz (2002) and Hall et al. (2001, 2002) introduced innovation system to the study of developing countries agriculture and agricultural research systems. At the national and regional level the concept was adopted in sub-Saharan Africa by Samberg (2005), Roseboom (2004), Chema (2003), Gilbert and Roseboom (2003), Peterson, Gijsbera and Wilks (2003), and Hall and Yoganand (2004), in Latin America by Vieira and Hartwich (2002) and in India by Hall et al (1998). Generally, most of its application across countries focused on institutional arrangements in research and innovation. For example Hall et al. (2002) emphasized on public-private interactions in agricultural research in India; and in south Asia and sub-Saharan Africa. Allegri (2002) and Kangasmemi (2002) focused on producers organizations. Other scholarly studies focused on technologies opportunities, for example zero tillage cultivation survey in Argentina conducted by Ekboir and Parallada (2002) which revealed social, and economic change that encouraged the diffusion of zero-tillage cultivation. Speilman (2005) thus concluded that the application of innovation system analytical framework to agriculture is embeded within the wider context of institutional change, change process, and answers certain questions that the linear, conven-tional research and systems are unable to address.

POLICY IMPLICATIONS FOR AGRICULTURAL EXTENSION DELIVERY IN NIGERIA

The application of innovation system analytical framework to agriculture is becoming popular and gaining interest, particularly among policy makers and planners. However, it presents major policy implications for extension delivery. Firstly government and policy makers should promote, support and sponsor intensive researches in sectors, sub-sectors or commodities of interest, using this system analytical framework to understand the strength, weaknesses, alternative direction for policies and programmes and support organizations that could contribute to strengthening the innovation system.

Viewing the actors in the agricultural research, education, extension and farmers system as equal partners, whose interaction/linkages determine the innovative performance of the economy, demands that the government should re-examine the polices that determine the statutory position, modus-oparandi and management style of the actors. Government should enact policies that are matched with action to create enabling environment for wider stakeholders participation in research and extension. The administrators and planners should adopt flexible management style that could encourage private sector interaction with the public sector; backed up with institutional guidelines for the linkage interactions.

It is also important that government and administrators should facilitate and promote orientation and building linkage leadership capability to sensitize and build positive attitudes among stakeholders. The private sectors as well as the farmers, innovate, collaborate and contribute to innovation process. Government should therefore enhance their innovative strength by enacting favourable policies (patenting and reward system) that will act as incentives. Extension should be more inclusive in documentation and transfer of innovations, expand technology transfer mandate, facilitate farmer innovations and build capability to analyze the same for social and economic development.

Moreover, extension approaches should explore and promote not only technical innovations, but also institutional, organizational and managerial innovations. Presently most extension strategies, for example the T and V system specifically focused on technical competence of agents and farmers, reflected in training prgrammes and methods. Little or no attention is devoted to building capability to facilitate and explore these categories of innovations through interaction and institutional learning. Policy makers should provide policy guidelines and framework to facilitate and foster interactions to spur innovations in this direction for all stakeholders incuding farmers, commodity traders, processing industries related to agriculture, transporters, input and service suppliers as well as trade organizations, private consultants, NGOs and CBOs.

Finally, innovation system argues that institutional context in which technological change occurs rather than technological change drives development. In practice extension agencies direct efforts on trial adaptation and dissemination of blue print recommendations from research. Most often, the policy and institutional environment (infrastructure, policies, transportation, and others) that determine the outcome of innovation process are not adequately examined. Policy makers should enact policies and processes to guide analysis of institutional context of innovations being promoted, while extension should build such information into technology packages to the farmers.

CONCLUSION

As argued in this paper, science and technology has received considerable attention in government as the major panacea for exponential growth of the agricultural sector. Although knowledge is increasing, but the micro innovative strength and stakeholders participation are increasingly less developed. Research systems (NARS

and AKIS) have only emphasized knowledge and linkages among research and extension systems, with focus on the public research systems as the known source of knowledge. Several other factors such as micro economic, social institutional mechanism for flow of information, relevant actors, dynamics of knowledge economy were not considered as important in determining the outcome of innovation processes. Innovation system approach offers a more inclusive and holistic approach, emphasizing wider stakeholder participation, institutional context, and diverse knowledge source and linkage, and comparatively incorporates the mandates of reforms and new trends for agricultural development. The adoption of innovation system has major policy implications for extension delivery in Nigeria. In other words:

1. Government and extension administrators should promote among stakeholders the adoption of an agricultural innovation system perspective in policy analysis.
2. Policy makers should identify weak or missing components and linkages within the agricultural innovation systems and to take measures accordingly of innovations being promoted; while extension should built in such policy information into technology packages to the farmers.
3. Policy makers and administrators should entrench linkage mandates into policies establishing the research extension systems and strategies for increasing private sector involvement in development.
4. Government should encourage and promote farmers' and private sector innovation by enacting favourable policies (patenting, reward system), while extension administrators should by training build capabilities to facilitate, analyze and promote farmer innovations.

The study therefore concludes that the comparative advantage of innovation concept should be explored to evolve a dynamic agricultural system capable of combating the increasing challenges in the agricultural sector.

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