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Agriculture Innovation System Approach for Sustainable Agriculture Development: A Review

Rakesh Sharma[1], Rajinder Peshin[2] Sanjay Khar[3] and Arvind K. Ishar[4]

[1]*Agricultural Extension, Krishi Vigyan Kendra, Rajouri*
[2]*Division of Agricultural Extension Education*
[3]*Krishi Vigyan Kendra, Jammu*
[4]*Plant Protection, Krishi Vigyan Kendra, Rajouri*
Sher-E-Kashmir University of Agricultural Sciences and Technology of Jammu

Corresponding author:

Abstract

With the change in context of agricultural development, the innovation approaches has also changed. Different approaches namely National Agricultural Research System (NARS), Agriculture Knowledge and Information System (AKIS), farmer first and last, Participatory Rural Appraisal (PRA) and Public Private Partnerships (PPP) are/have come up to mitigate rapid changes over the years. The present agricultural research efforts are failing to bring about the social and economic transformations due to one or the other reasons. To cope, compete and survive in emerging challenges, it becomes necessary to develop new approaches. In this context, the concept of Agriculture Innovation System (AIS) approach offers a new framework for analyzing the role of science and technology and their interaction with other actors to generate goods and services. It recognizes the importance of certain types of relationships and linkages for information flow in ever-changing biophysical and social environments. There are some success stories of Agricultural Innovation System in the developing and the developed countries namely shrimp farming and small scale food processing in Bangladesh, medicinal plants and Vanilla sectors in India, Pineapple and Cassava processing sectors in Ghana and production and marketing of agricultural commodities by U.K Co-operatives in United Kingdom. Thus, the innovation is viewed in a social and economic sense and not purely as a discovery and invention. The concept of an innovation has guided a more holistic approach to planning knowledge production and use.

Keywords: National Agricultural Research System (NARS), Agriculture Knowledge and Information System (AKIS), Agriculture Innovation System (AIS)

The context for agriculture is changing rapidly and the process of knowledge generation and use has been transformed as well. Agricultural development depends to a great extent on how successfully knowledge is generated and applied. Investments in knowledge especially in the form of science and technology have featured prominently and consistently in most strategies to promote sustainable and equitable agricultural development at the regional and national level. Although many of these investments have been quite successful, the historical focus of research on food crop technologies, especially genetic improvement of food crops, has undeniably been successful. Yields of many commercial crops and livestock have grown rapidly. For most of the 20th century, major progress

in agricultural development was inextricably linked to major improvements in the productivity of staple food crops, but this situation is fast changing. With falling staple food prices and rising urban incomes, the payoff has shifted to strategies that enhance agricultural diversification and increase the value addition of agricultural production (Barghouti *et al.,* 2004). Despite their past prominence in driving agricultural development, centralized public research systems are finding it difficult to cater to this trend. In the changed context of agricultural development, the innovation approach has also changed. Over the years different approaches such as National Agricultural Research System (NARS), Agriculture Knowledge and Information System (AKIS), Farmer first and last, Participatory Rural Appraisal (PRA), Public Private Partnerships (PPP), local innovation and so forth have come up. It is increasingly recognized that traditional agricultural science and technology investments such as research and extension, although necessary, are not sufficient to enable agricultural innovation (World Bank, 2006). While traditional agricultural research organisations still have a role to play in providing some of this knowledge, what is now required is a much more flexible arrangement in which dense networks of entrepreneurs, farmers, research and training and policy organizations interact and respond to new circumstances. It is here that the innovation system concept has something new to offer with a view to create the dynamic innovation capacities that farmers firms and countries need in order to survive and grow in this environment. Although increasing the production of food crops is/will remain important, a new trend in agriculture is emerging in many new production-to-consumption systems. To cope, compete and survive in emerging challenges, it become imperative to develop new approaches. Different sources of knowledge are needed to deal with upcoming challenges, such as new regulations, consumer preferences, competitors, insect-pest and diseases, climate change, and human health problems. Fresh direction, however, is coming from recent insights which recognize that the innovation process involves not only research, but also a wide range of other activities, actors and relationships associated with the creation and transmission of knowledge and its productive use. As a framework for applying these insights, the concept of an innovation system is emerging as a potentially valuable tool to help rethink the role and contribution of agricultural research (Hall *et al.,* 2002).

Shortfalls in the Present Agricultural Research

There has been a wide recognition that agriculture research efforts are failing to bring about the social and economic transformations to the extent that their potential would suggest due to: ineffective technology transfer**,** incorrect research priorities and weak demand for research products**.** Against the backdrop of these shortfalls, agricultural research requires institutional changes. The old conceptualization of research leading to technology and in turn to economic production is no longer adequate. While the production, sale and consumption of major food crops remains important, a number of niche sectors are emerging with impressive rates of growth such as:

- A much greater role of the private organizations, cooperatives and civil society sectors.
- The delineation of new and dynamic niche sectors such as export horticulture and agro processing which are knowledge-intensive.
- The policy recognition of the importance of upgrading and innovation not only in hitech sectors, but also traditional sectors including the natural resources and the need to both compete internationally and add or retain value in country.
- Rapidly evolving production, consumption and marketing conditions driven by new technology, globalization, urbanization and associated phenomenon such as the industrialization of the food chain and the consequent importance of innovation as a source of competitive advantage in these conditions.

Changing Approaches for Supporting Agricultural Innovation

With the change in agricultural development process, ideas of what constitutes innovation have changed, and so have approaches for investing in it. In the 1980s, the concept of the "National Agricultural Research System," or NARS, was developed to guide investments in agricultural development. Development activities based on the NARS concept generally focused on strengthening research supply by providing infrastructure, capacity, management, and policy support at the national level. The NARS framework has been effective in creating agricultural science capacity and in making improved varieties of major cereals crops but framework is poorly suited for responding to rapidly changing market conditions and for providing technologies for producers to supply emerging, high-value niche markets. It was realized that research is not the only means of generating or gaining access to knowledge, the concept of "Agricultural Knowledge and Information System" (AKIS) gained popularity. The AKIS concept also focuses on research supply, it gives much more attention to the links between research, education, extension and the identification of farmers' demand for new technologies. Strengthened research systems may increase the supply of new knowledge and new technologies, but they may not necessarily improve the capacity for innovation throughout the agricultural sector (Rajalahti, Woelcke, and Pehu 2005). The AKIS concept recognizes that multiple sources of knowledge contribute to agricultural innovation and gives attention to developing channels of communication between them. The addition of educators to the framework is notable. The AKIS framework clearly recognizes that education improves farmers' ability to engage in innovation processes but the AKIS model is also suffering from some shortcomings such as the focus is restricted to actors and processes in the rural environment, and the framework pays limited attention to the role of markets (especially input and output markets), the private sector, the enabling policy environment, and other disciplines/sectors. More attention has been given to the demand for research and technology and to the development of wider competencies, linkages, enabling attitudes, practices, governance structures, and policies that allow this knowledge to be put into productive use. The concept of an agricultural innovation system has guided this more holistic approach to planning knowledge production and use.

Agricultural Innovation System Concept

The agricultural innovation system concept marks a sharp shift from earlier thinking on innovation as linear process of R&D leading to technical and economic change. It extends beyond the creation of knowledge to encompass the factors affecting demand for and use of new and existing knowledge in novel and useful ways. Thus, it is viewed in a social and economic sense and not purely as a discovery and invention. The innovation systems concept is attractive not only because it offers a holistic explanation of how knowledge is produced, diffused, and used but also because it emphasizes the actors and processes that have become increasingly important in agricultural development. The concept gives centre stage to two interconnected dimensions of innovation. *First* is the interaction among different players in economic systems, the roles they play and the way their interaction facilitates the transmission, adaptation and use of ideas, and thus enables learning and innovation. The *second* dimension is the way the process is located in, shaped by and responds to various contexts. These includes the habits and practices (institutions) of the various actors involved in innovation; the historical, cultural and political setting that gives shapes to habits, practice and styles of innovation; and the enabling environment that includes some of these other contextual elements, but also includes policies and infrastructure as well as the market itself as a mechanism for providing incentives for entrepreneurial activity. Two other important considerations that the innovation systems framework allows one to reveal are the dynamics of the processes involved and the capacity that emerges at a systems level. So while the concept recognizes the importance of certain types of relationships and linkages that mediate information

flows, it also recognizes that in ever-changing biophysical and social environments (climate, weather, markets, policy, technology), patterns of linkages need to change to meet new conditions and demands. To recapitulate some of the points made earlier, agricultural development plans are no longer concerned almost exclusively with staple food production. These plans now give far more attention to diversifying into new crops, products, and markets and to add value to serve new markets better (Barghouti *et al.*, 2004). These changes are driven by rapid urbanization and by the increased integration of many developing countries into global markets for agricultural products and services. This market-led agricultural development relies more strongly on the private sector and on the interaction of agriculture with other sectors and disciplines. Because new markets for agricultural products and services change continuously, agricultural development depends more than ever on a process of continuous, incremental innovation. The scope of innovation includes not only technology and production but also organizations (in the sense of attitudes, practices, and new ways of working), management, and marketing changes, therefore requiring new types of knowledge not usually associated with agricultural research and new ways of using this knowledge.

Origin of the Agricultural Innovation System Concept

The innovation system concept emerged through policy debates in developed countries in the 1970s and 1980s. According to Arnold and Bell (2001), the linear model of innovation mirrored the belief that "basic science leads to applied science, which causes innovation and wealth." The policy implications of this "science push" model was simple: "If you want more economic development, you fund more science." As more attention was given to the role of market forces in innovation, a corresponding and equally linear "market pull" model of innovation was developed. In contrast, Arnold and Bell's depiction of a national innovation system shows the multiplicity of "actors and activities in the economy which are necessary for commercial innovation to take place and to lead to economic development". The central insight is that innovation depends as much on the performance of linkages between actors as on the performance of individuals. The implication, according to Arnold and Bell, is that "certain system characteristics such as stronger links between actors are likely to improve performance". The set of potentially important actors in an innovation system differs from the string of suppliers and clients arranged along a classic value chain or the set of organizations involved in

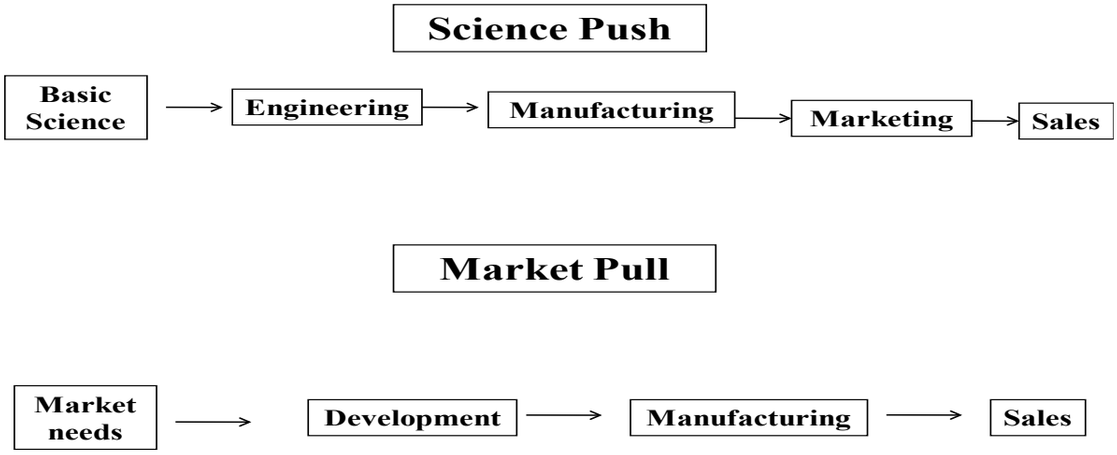

Fig. 1. Linear Models of Innovation

Source: Arnold and Bell (2001)

Table 1. Case Studies of Agriculture Innovation System

Sector and Country	Government	Private sector	NGOs	Farmer-Owned Enterprises, co-operatives and similar
Shrimp, Bangladesh	**Initially:** None **Later:** Sector specific policies and development of infrastructure	**Initially:** Started processing factories **Later:** Lobbied govt. for sector support	**Initially:** None **Later:** Bangladesh rural advancement development in production and sale	Role unclear
Small scale food processing Bangladesh	**Initially:** None **Later :** Policies tended to support large scale export	**Initially**: Activities of micro scale Entrepreneurs **Later:** Developing networks of small scale producers in rural areas and training in food processing	**Initially:** Training of the poor in food processing activities **Later :** Support for business development skills, research on social and technical aspects and access to credit	**Initially:** None **Later :** Develop network based production
Medicinal plants India	**Initially:** Little **Later:** Creation of Department of Indian Systems of Medicine and Medicinal Plants Board	**Initially:** Companies **Later:** Emergence of large scale manufacturing companies	**Initially:** Limited **Later:** Establishment of NGOs to act as coordinating body	**Initially:** None **Later:** An example of a collector owned company established to reduce exploitation by middlemen
Vanilla India	**Initially:** Limited, despite presence of government body designed to oversee spice sector development **Later:** Main purchaser of vanilla	**Initially:** Main source of planting material in early stages of sector development	None	**Initially:** Farmers associations main source of diffusing production and post harvest innovations among farmers **Later:** Producers own companies important marketing innovation in response to falling prices
Pineapple Ghana	**Initially:** None **Later:** Export policy support	**Initially:** Main actors **Later:** Main actors in expanding the sector and also play role in multiplying and distributing planting material.	**Initially:** None **Later:** Specialist technical assistance and linkage brokering NGOs activity in supporting the establishment of companies	**Initially:** None **Later:** Producers owned company established by the name of Farmappine
Cassava processing Ghana	**Initially:** Research and policy support **Later:** Research better integrated with actors in value chain, although still much scope for improvement	**Initially:** Limited **Later:** Became an active partner in the sector for responding to both market and policy incentives.	**Initially:** Active in technology transfer **Later:** Starting to play the role of intermediary organizations	Unclear

United Kingdom[2]	Govt. policies to reduce pesticide use. Govt. and cooperative contributed a grant of £4.3 million and 150000, respectively for protection of honeybees	Production and sale of biocontrol agents	Role unclear	U.K Co-operative group is owned by the farmers who produce and market it through their outlets. The UK cooperative group Banned use of endosulfan in 2009

Source: World Bank (2006);2.http://www.co-op.co.uk

public sector research. There is no assumption that an innovation process starts with research or that knowledge feeds directly or automatically into new practices, processes, or products. Instead, the knowledge and information flows at the heart of an innovation system are multidirectional. They open opportunities for developing feedback loops that enhance competence building, learning, and adaptation. All too often, the right kinds of actors are absent, or they do not interact in ways that support the innovation process. The innovation systems concept helps to reveal why these interactions might not be present and what might be done to remedy this problem.

Success Stories of the Agricultural Innovation System Concept

There are some success stories of Agricultural Innovation System in the developing and the developed world (Table 1) for example, shrimp farming and small scale food processing in Bangladesh, where initially there was no government and NGO support for these enterprises. The private sector was only involved for processing in case of shrimp. Later on, these above referred agencies played a complementary role. The government framed the policies after the private sector lobbied and financed the shrimp farming and small scale food processing, but still the role of research is limited. Medicinal plants and Vanilla sectors are few examples of developing innovation system. The actors in the Agricultural Innovation System are Government, private sector, NGOs and farmers (Table 1). It resulted in the establishment of medicinal plant board, large scale private sector innovative manufacturing. The NGOs act as coordinating body for rural development through medicinal growers who have eliminated the middlemen's role by establishing their own company. Pineapple and Cassava processing sectors in Ghana are other cases where initially government plays no role and private sector is the main actor in establishing the pineapple sector (Table 1). U.K Co-operative is the worlds largest co-operative owned by the farmers who are involved in production and marketing of the agricultural commodities. This cooperative has played a great role in putting in place IPM innovation system, where by government and the farmers contribute financially in producing IPM products for sale through their outlets. Even though, the government of U.K has not yet banned the toxic endosulphan, but the U.K cooperative has banned it on their farms (Table 1).

Conclusion

The earlier systems namely NARS and AKIS have been effective in creating agricultural knowledge but were suffering from certain shortcomings: these systems are poorly suited for rapidly changing market conditions and high-value niche markets. Moreover, they pay less attention to the role of markets, the private sector, the enabling policy environment, and other players. Therefore, in the rapid changing biophysical and social environment, certain types of relationships and linkages are recognized for better flow of information. For that, the agricultural innovation system approach**:**

1. Offers a new framework for analyzing both the roles of science and technology and their interaction with other actors to generate goods and services.
2. Will be very effective in identifying the

missing links in traditional sectors and potentially improving the innovation dynamics. This dynamism often depends on the presence of some sector while coordinating capacity for identifying innovation challenges and pursuing novel approaches to innovation.

3. Promotes the integration of poverty and environment issues into sector development planning by altering the roles and interactions of actors in the public sector, the business community, and civil society.

4. Provides a framework for inclusive, knowledge-intensive agricultural development, but more experience is required before the contours of a truly pro-poor, pro-environment, and pro-market innovation system can be fully defined

References

Arnold, E., and Bell, M. 2001. "Some New Ideas about Research for Development." In *Partnerships at the Leading Edge: A Danish Vision for Knowledge, Research and Development.* Report of the Commission on Development-Related Research Funded by Danida. Copenhagen: Ministry of Foreign Affairs/Danida. Pp. 279-319.

Barghouti, S., Kane, S. Sorby, K. and Ali, M. 2004. "Agricultural Diversification for the Poor: Guidelines for Practitioners." *Agriculture and Rural Development Discussion Paper 1*. World Bank, Washington, D.C.

Hall, A. J. 2002. "Innovation Systems and Capacity Development: Agenda for North South Research Collaboration?" *International Journal of Technology Management and Sustainable Development* **1**(3): 146–52.

Hall, A. J. 2006. "Public-Private Sector Partnerships in a System of Agricultural Innovation: Concepts and Challenges." *International Journal of Technology Management and Sustainable Development* **5**(1).

Rajalahti, R. Woelcke, J. and Pehu, E. 2005. "Development of Research Systems to Support the Changing Agricultural Sector." *Agriculture and Rural Development Discussion Paper 14*. World Bank, Washington, D.C.

World Bank. 2006. *Enhancing Agricultural Innovation: How to go Beyond the Strengthening of Research Systems.* World Bank, Washington, D.C