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Integrating innovation systems perspective and value chain analysis in agricultural research for development: Implications and challenges

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Integrating innovation systems perspective and value chain analysis in agricultural research for development: Implications and challenges

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Table of Contents

List of Figures iv

Acknowledgements v

Forward vi

Abstract vii

1 Introduction 1

2 Changing paradigms and contexts in agricultural R&D 3

2.1 Changing paradigms, contexts and on-going reforms 3

2.2 Emerging challenges in agricultural R&D 4

3 Agricultural innovation system perspective 9

3.1 What is a system? 9

3.2 What is innovation? 9

3.3 What is innovation system? 10

3.4 What is innovation systems perspective? 18

3.5 Factors contributing to successful innovation 19

4 Agricultural value chains and value chain analysis 22

4.1 Basic concepts in agricultural value chain analysis 22

4.2 The agricultural value chain analysis approach and purpose 27

5 Integrating innovation systems perspective and value chain analysis in agricultural research for development 32

5.1 Innovation systems and value chain analysis 32

5.2 Integration in the design and implementation of AR4D 34

6 Implications and challenges 38

6.1 Implications 38

6.2 Challenges 41

7 Conclusion 44

References 46

Annex 1: Evolution of the Application of Innovation Systems Concept in Agriculture 50

Annex 2: The Process of Value Chain Analysis 57

List of Figures

Figure 1. National system of innovation—Generic concept 11

Figure 2. National agricultural innovation system 13

Figure 3. Typical commodity based innovation system 16

Figure 4. Typical agricultural value chain and associated business development services 23

Figure 5. Integration of value chain and innovation 35

Figure 6. Integration of research and development, value chain and innovation systems perspective 37

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Forward

Over the years, the agricultural R&D arena has seen a number of paradigm shifts and transformation. This has serious implications in the way the agricultural research is conceived, designed, implemented, evaluated and how the results are disseminated and used to generate innovations. Currently the agricultural research processes are guided by four complementary concepts and principles: the innovation systems perspective, value chain analysis, impact orientation and integrated research for development. One of the frequently asked questions by the researchers and research managers is how these concepts can be integrated and applied in the real world research processes. This paper is primarily addressing the issue of integration of value chain analysis and innovation systems perspective in the agricultural R4D processes.

Although a number of stakeholders within the agricultural innovation system are interested in these concepts, the target audiences for this paper are the agricultural researchers and university educators. The authors also assume that the reader is familiar with the participatory research processes. We encourage the readers to provide constructive feedback in order to move this integration process forward.

Authors

Abstract

The environment in which agricultural discovery and innovation occurs has been constantly changing with resultant significant influences on the organization and the social processes of discovery and innovation. As a result, there have been significant paradigm shifts in agricultural knowledge generation, dissemination and utilization. Currently, the knowledge generation, dissemination and utilization processes within the agricultural sector are guided by four complementary and mutually reinforcing concepts and principles: the innovation systems perspective (ISP); value chain approach; impact orientation; and research for development (R4D). Impact orientation and R4D are implicit in the concept of ISP. A major challenge confronting the agricultural research for development (AR4D) community is how to integrate these different concepts in the design, implementation and evaluation of AR4D. However, an operational model that integrates ISP and value chain approach into AR4D is lacking. This paper is an attempt to develop such an operational model. The paper also addresses the emerging issues and challenges in the integration process and its institutionalization within the broader framework of AR4D.

1 Introduction

Over the past four decades the international consensus on the importance of agriculture in economic development has varied from very high (until 1980s), to very low (until 1990s) to the current rediscovery. Now, there is growing consensus that in the 21st century agriculture remains fundamental for poverty reduction, economic growth and environmental sustainability for agriculture based countries (World Bank 2008). Agriculture contributes to economic development in many ways (World Bank 2008): (i) as an economic activity and leading sector for economic growth, (ii) as a source of livelihood, (iii) as a provider of environmental services and (iv) as a contributing factor to peace and stability by providing food to the growing population at an affordable price.

Enhancing smallholder productivity and sustainable economic growth are pre-requisite to achieve the full contributions of agriculture to overall growth and development. Increasingly, developing countries are viewing science and technology as the drivers of economic growth—and agricultural research and development is expected to play a significant role in the process.

The scientific methods of experimentation and discovery have not changed since their exposition in the 19th century. What changes constantly is the environment in which discovery and innovation occurs which influences the organization and the social process of discovery and innovation. Since the time organized research was introduced into the developing world, especially in sub-Saharan Africa (SSA), there have been significant paradigm shifts in agricultural knowledge generation, dissemination and utilization. The emerging paradigms while including many elements of indigenous knowledge (ethnic science) and modern science also encompasses major reforms in social, technological, organizational and institutional approaches. In responding to these changes, there is a gradual evolution of the central source model of innovation of the 1970s and 1980s to the current agricultural innovation systems approach. This evolution occurred as a result of the identified weaknesses of the predominant paradigm of the time, and the emerging challenges and needs of the society. This evolution is additive and based on the existing frameworks.

Currently, the knowledge generation, dissemination and utilization processes within the agricultural sector are guided by four complementary and mutually reinforcing concepts and principles: the innovation systems perspective; value chain approach; impact orientation; and research for development (R4D). However, it is worth noting that the impact orientation and the R4D are implicit in the concept of innovation. Much has been written on these topics. However, one of the key lingering issues is how to integrate these different concepts in the design, implementation and evaluation of agricultural research for development (AR4D). The lack of clarity in some of these concepts and the absence of an operational model to guide the research process has been a critical constraint for the effective institutionalization of the concepts. This paper is an attempt to address this practical challenge confronting the research community in their daily professional activities.

This paper is organized into seven sections. The next section deals with the on-going transformation within the agricultural R&D arena and the emerging challenges. Section three looks at the evolution and concept of the innovation system approach, and section four deals with agricultural value chains and value chain analysis. Section five looks at the integration of innovation system perspective and agricultural value chain analysis in an impact-oriented R4D, while section six deals with implications and challenges confronting development practitioners. The final section concludes the paper.

2 Changing paradigms and contexts in agricultural R&D

2.1 Changing paradigms, contexts and on-going reforms

Over the years, the R&D arena has seen a number of paradigm changes and transformation, and there are a number of emerging issues that pose new challenges to the R&D practitioners. Some of the key changes that will have a profound effect on the priorities of the R&D practitioners are discussed in this section.

Recent studies (Biggs and Smith 1998; Hall and Nahdy 1999; Ashby et al. 2000; Chema et al. 2003; Paterson et al. 2003) showed that many organizations, especially publicly funded agencies dealing with agricultural R&D in developing countries are facing a crisis of confidence among key stakeholders due to lack of strategic planning that indicates future directions; inward looking attitudes; poor participation and cooperation of end-users in research activities; inadequate monitoring and evaluation systems; top-heavy, bureaucratic procedures; insufficient resources for effective implementation of priority research; lack of effective external linkages; and lack of evaluation and performance culture.

These issues have been found to result in organizational inefficiencies, lack of adequate stakeholder participation and responsiveness, decreasing investor confidence, inadequate staff motivation and low moral, limited research and service outputs, limited uptake and utilization of research findings and a 'brain-drain' from the public sector. At present the three core institutions in the agricultural knowledge triangle (research–extension and higher education) have been down sized and restructured in many developing countries and new private institutes are now in stiff competition with public counterparts. This competition is also forging new partnerships.

As a result, the policy organizational and institutional context in which agricultural research and innovation occurs has changed dramatically. Rapid changes are taking place in the structure and authority of governments, the global economy, the structure of the farming sector, and in the global and local food industries and retail businesses. The institutional landscape is also changing dramatically. For example, civil society, farmer organizations and NGOs are playing important roles in agricultural R&D. Cross-sectoral linkages between agricultural and other sectors (such as water, health, energy and education) are becoming more important. The agricultural sector is expected to play a significant role in poverty alleviation, and food and nutrition security, while protecting the environment. With reduced funding, the agricultural R&D systems are now forced to raise questions about their continuing relevance, approaches, accountability and impact. Funding for research and support services can no longer be separated from the broader developmental questions.

The reform agenda in R&D debates include: redefinition of the role of government in agricultural R&D; decentralization and privatization of agricultural R&D activities; market-oriented agricultural development; broader and active stakeholder participation in service provision; increased networks and partnerships; new funding arrangements (such as the separation of financing from service provision and research execution and changing the funding base to competitive funding), market liberalization; food and environmental safety; and effective use of ICT in knowledge management. Given the sweeping reforms that are taking place, the R&D systems are facing a transition period in which they will need to restructure themselves, confront new demands, and adjust to new political, scientific, institutional and economic environments. Exogenous trends contributing to the reform process are changes in the political, socio-economic, market and institutional context together with changes in the demand for R&D services, research technologies, methodologies, and approaches. Managing this complex environment requires a range of skills and tactical planning and shifts in paradigms.

Over the years, a number of paradigm shifts have occurred within the R&D arena. These include farming systems perspective (Matata et al. 2001); participatory research methods (including action research); agricultural knowledge and information system (AKIS) (Rolling 1986, 1988); rural livelihoods (Christopolis et al. 2001); agri-food systems/ value chain; knowledge quadrangle; Doubly Green Revolution (Conway 1999); and Rainbow Revolution (UN 2006); innovation systems perspective (including networks and partnerships); and integrated agricultural research for development (IAR4D) (ASARECA 2007). Some of these concepts are short-lived; others have contributed to the evolution of the current prevailing paradigms of innovation systems perspective, value chain analysis and integrated agricultural research for development. These reforms and paradigm shifts have great potential in enhancing the significance and efficiency of agricultural research, but in practice their success will depend on how well they are applied and modified to the diverse local conditions (Chema et al. 2003; Eicher 2006).

2.2 Emerging challenges in agricultural R&D

In the recent past, the agricultural sector has witnessed a number of changes in the context in which it operates. These changes cause challenges as well as offer new opportunities. Some of the key challenges facing the agricultural sector in developing countries are briefly presented below.

i Emerging financial crisis

The current financial crisis is contributing significantly to the economic slowdown of many countries resulting in reduction in the capital availability at a time when accelerated investment is urgently needed in the agricultural research and development arena.

The projected low economic growth is likely to have negative second-round effects for investment and productivity with direct ramifications for food prices and food security around the globe. von Braun (2008) concluded that if the developing countries and investors can maintain agricultural productivity and investment under recession, they can avoid many of the negative effects of slower growth. Given the current financial crisis, much of the needed investment would have to be facilitated by public sources.

ii Emerging food and energy crisis

In the recent past, global food prices are increasing at an unprecedented rate and analysts say that they will continue to remain high for a considerable period.

The long-term solution to the current crisis is increasing the supply capacity—a positive supply response. However, this response for better price incentives depends on public investments in markets, infrastructure, institutions and support services. In order to address the current food crisis, countries need a comprehensive plan to ensure long-term food availability and security as well as short term relief. They also must invest now and for the longer term in problem solving agriculture.

iii Recent technological advances in biotechnology and ICT

Biotechnology has provided unparallel prospects for improving the quality and productivity of crops, livestock, fisheries and forestry. Conventional biotechnologies have been around for a very long time, while genetic modification (GM) technologies have emerged more recently. GM technologies are making rapid progress worldwide. Africa lacks capacity and resources to move biotechnology research forward. Countries have not yet developed proper legislative frameworks on bio-safety of GM organisms (Eicher 2006).

The revolution in ICT and increased access to them in developing countries is enabling a variety of new approaches to capacity building and knowledge sharing. However, exploitation of these opportunities require additional investments.

iv Climate change

Climate change could create changes in the geographical production patterns, as well as deterioration of natural resource base due to scarcity of water and rising temperature. Pressure on resources will lead to degradation of land, water and animal genetic materials in both the intensive and extensive livestock systems. Climate change will also affect parasites like the tsetse fly and parasitic diseases such as malaria. Research and development efforts can play a significant role in responding to the challenges of climate change and mitigating and adapting to climate-related production risks.

v Trade, market liberalization and the emerging agri-food system

Emerging market liberalization, trade reforms and globalization are transforming national and regional economies and the farming sector. The global and national food systems are increasingly being driven by consumer interests, changing consumption patterns, quality and safety concerns and the influence of transnational corporations and civil society organizations.

Enhancing smallholder participation in high-value and emerging markets requires upgrading farmer's technical capacity, risk management instruments and collective action through producer organizations. Addressing the stringent sanitary and phytosanitary standards in global markets is even a bigger challenge. Small-scale producers also must follow these rules if they are to go ahead. The potential for rural economic development would remain very limited if the production and marketing strategies are based exclusively on traditional agricultural production, frequently oriented in selling surplus (supply) rather than market. To make use of the emerging opportunities and make economic progress, rural producers must not only improve quality and offer new products with greater value added, but also need an organizational arrangement that link and coordinate producers, processors, merchants and distributors of specific products (PAPA 2008).

vi Emerging diseases

The incidence and impacts of diseases such as HIV/AIDS and malaria are well documented. These two diseases and the associated health complications constitute the greatest threat to food security and poverty alleviation. Additional threats and challenges are posed by highly pathogenic emerging diseases which are transmitted between animals and humans. Serious socio-economic consequences occur when diseases spread widely within human and animal populations. Building sustainable capacity for innovations in disease surveillance and control at national, subregional and continental levels is another challenge confronting the R&D practitioners.

vii Growing need for intersectoral linkages

One of the major constraints to getting agriculture moving in developing countries is the general lack of comprehensive policies and weak intersectoral linkages. Now there is growing awareness that a number of sectors such as agriculture, education, health, water, and energy are very closely linked. Thus any agenda to transform the smallholder agriculture should follow a multi-sectoral approach and capture the synergies between technologies (seeds, fertilizer, livestock breeds); sustainable water and soil management; institutional services (extension, insurance, financial services); and human capital development (education and health)—all linked with market development (World Bank 2008).

viii Changing expectations of science and technology and innovation

Over the years, there has been a significant change in the expectations of science and technology and innovations, from increasing crop and livestock productivity to creating competitive, responsive and dynamic agriculture that directly contributes to the Millennium Developmental Goals (MDG). This leads to competitive agriculture which will result in market-driven exchange of both knowledge and products and also viable in domestic, regional and global markets. Moreover, they should respond to the multiple needs of small farmers, agribusinesses, food insecure groups, wealthy households, and should be dynamic enough to be able to adapt to long-term agro-ecological changes, medium-term structural changes and short-term shocks (Spielman 2008).

ix Globalization of private agricultural research and innovation

In the recent past, there is a trend towards globalization of private agricultural research. Drivers of globalization of R&D are growing markets for agricultural products and agricultural inputs (reduced restrictions on trade in agricultural inputs), new technological opportunities due to breakthrough in biotechnology; improved ability to appropriate the gains from innovations, improved policy environment for foreign investments and technology transfer and growth in demand due to increased income and policy changes (Pray 2008). If carefully nurtured and managed, this may offer additional opportunities for public–private partnership, to mobilize additional resources and to move the poverty reduction agenda forward.

x Greater concern for the environment

Since the 1992 Earth Summit in Rio, it is generally accepted that the environmental agenda is inseparable from the broader agenda of agriculture for development. Both intensive as well as extensive agriculture can lead to environmental consequences. The solution to these problems is to seek more sustainable production system and enhancing agricultural potential for provision of environmental service (World Bank 2008). This is crucial when discussing agriculture for development as one of the developmental goals is the sustainability of the natural resources.

To sum up, there is a need for agriculturalists to change intellectually and operationally from a narrow focus on agriculture and technological research and dissemination to a better understanding of rural societies and their needs. There is a need to seek greater understanding of alternative pathways for rural economic development, placing the role of agriculture in perspective, and redefining the role, mission, and strategy of the agricultural institutes and agents as facilitators of rural economic growth. This calls for the change in the mind sets of the change agents and greater flexibility and creativity in defining the agenda as well as in defining new public–private–civil society partnerships on the basis of whatever is necessary to improve opportunities, productivity and income generation capacity of poor rural households.

3 Agricultural innovation system perspective

3.1 What is a system?

A system is a collection of related elements that must function in concert to achieve a desired result (Bean and Radford 2002). It consists of interlinked subsystems, but is more than the sum of its subsystems, with the central feature being its integrity and synergy. A system contains one or more feedback loops which are central to the system behaviour and permits a system to function in a self-managed, self-sustained way. The two key conclusions emerging from the system thinking are that the interrelated parts drive the system, and the feedback loops are circular rather than linear.

The systems thinking is not new to agriculture. The earliest work in systems has its roots in early 20th century biology. Its systematic application in the agricultural sector began in the mid 20th century. The application of the 'systems' concept in agricultural R&D started with the farming systems research to address the farm level productivity constraints in the 1970s. Now the use has expanded to the application in organization and institutional analysis, resulting in the 'agricultural innovation systems' concept. The following sections of this paper trace this evolution and its implications for agricultural R&D management.

3.2 What is innovation?

In the literature different authors have defined the term innovation differently (EC 1995; Quintas 1977 as cited in ISNAR 2001; Drucker 1998; OECD 1997). Freeman, 1982 defined innovation as '…the technical, design, manufacturing, management and commercial activities involved in the marketing of new (or improved) product or the first commercial use of a new (or improved) process or equipment'. However, Rothwell (1992) reminded that innovation is not always about radical change 'innovation does not necessarily imply the commercialization of only a major advance in the technological state-of-the art … but it includes also the utilization of even, small scale changes in technological know-how'.

The simplest definition is 'anything new introduced into an economic or social process' (OECD 1997). The most useful definition of innovation in the context of R&D is 'the economically successful use of invention '(Bacon and Butler 1998). Here invention is defined 'as a solution to a problem'. This allows us to make the distinction between knowledge and innovation. Taking a brilliant idea through, on an often painful journey to become something which is widely used, involves many more steps and use of resources and problem solving on the way.

In the past, science and technology generation were equated with innovation. It is crucial to recognize that innovation is strongly embedded in the prevailing economic structure, which largely determines what is going to be learned and where the innovations are going to take place. Moreover, such innovations are not limited to technological (both product and process) innovations only but also include institutional, organizational, managerial and service delivery innovations. This also emphasizes the notion that the responsibility of agricultural research organizations does not end with the production of new technology or knowledge only. They can claim success when their inventions are being disseminated, adopted and used (Chema et al. 2001).

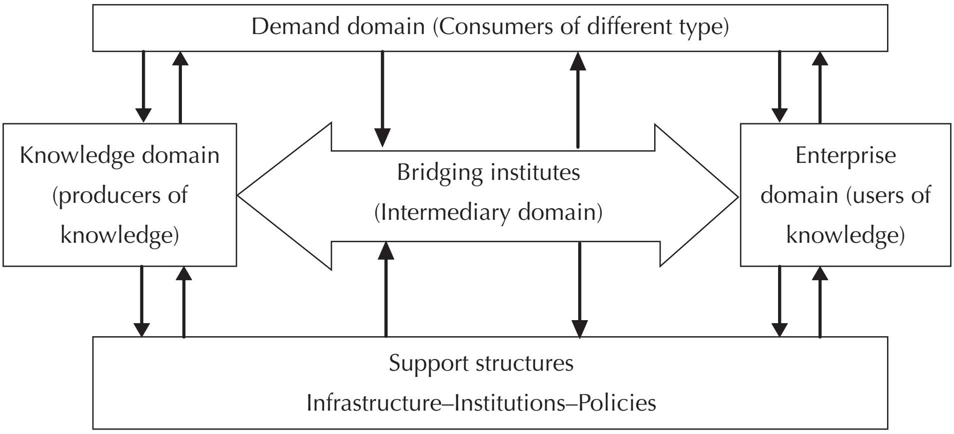
Innovations are new creations of economic significance. They relate to the production of new knowledge and/or new combination of existing knowledge. The critical point to note is that this knowledge cannot be regarded as innovation unless it is transformed into products and processes that have social and economic use (Edquist 1997). This transformation does not follow a linear path but rather characterized by complicated feedback mechanisms and interactive relations involving science, technology, learning, production, policy and demand. The use of the term innovation in its broadest sense covers, the activities and processes associated with the generation, production, distribution, adaptation and use of new technical, institutional and organizational, managerial knowledge and service delivery (Hall et al. 2005).

3.3 What is innovation system?

An innovation system is the group of organizations and individuals involved in the generation, diffusion, adaptation and use of new knowledge and the context that governs the way these interactions and processes take place. In its simplest, an innovation system has three elements: the organization and individuals involved in generating, diffusing, adapting and using new knowledge; the interactive learning that occurs when organizations engage in these processes and the way this leads to new products and processes (innovation); and the institutions (rules, norms and conventions, both formal and informal) that govern how these interactions and processes takes place (Horton 1990). People working on similar issues, be it in a specific commodity sector, at a particular location or in any problem area tend to form a chain or network that can be described as innovation system. An innovation system can be defined at different levels: national, sectoral, commodity and intervention based. These are discussed in the following subsections.

3.3.1 National innovation system (NIS)

NIS is defined (World Bank 2008) as a set of functional institutions, organizations and policies that interact constructively in pursuit of a common set of social and economic goals and objectives, and that uses the introduction of innovation as the key promoter of change. At its simplest, this concept states that innovation emerges from evolving systems of actors, their interaction and processes that are involved in research and the application of research findings for socioeconomic benefit. A NIS concept will allow better understanding of the governance, resource allocation and outcomes in the short, medium and longer term. The concept of NIS is a generic concept, which has three components: the knowledge domain, business domain and the environment as shown in Figure 1.



Sources: Adapted from Arnold and Bell (2001); Birner (2008); Rajalahti et al. (2008).

Figure 1. *National system of innovation—Generic concept.*

The concept of NIS was first mentioned in the industrial innovation literature in the late 1980s. The study of NIS started with relatively simple descriptive analysis that tried to explain the difference in innovative activity and performance between countries. More recently, however, the theoretical underpinning of NIS approach has been substantially improved by the addition of insights from various streams of thinking, including evolutionary economics, theories of learning, institutional thesis and systems theory (Roseboom 2004). NIS is simply an analytical tool that can be used for planning and policymaking to enhance innovations.

NIS permits actors and stakeholders within the system to identify their distinctive roles and understand their relationships to others in the system. The net result is the potential for better articulation, identification of gaps and challenges, and greater agreement, at least in principle, on the future requirements for the system (Paterson et al. 2003).

The important characteristics of NIS and the lessons learned (Metcalfe 1995; Arnold and Bell 2001; Roseboom 2004; Hall et al. 2005) included:

- NIS place emphasis on interdependence and non-linearity in innovation process, and on demand as a determinant of innovation.

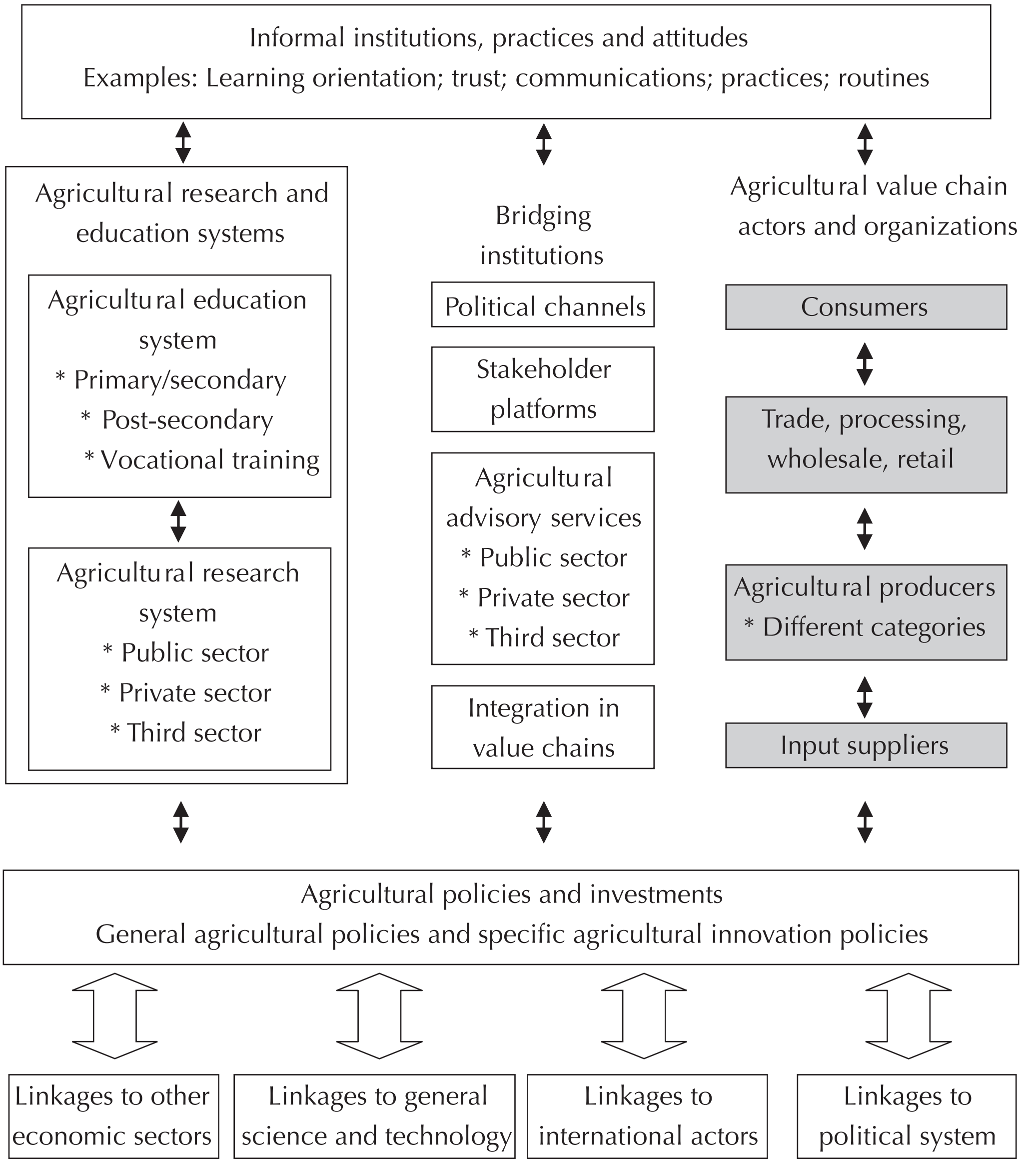
- They are strongly influenced by evolutionary thinking. A unique optimal NIS does not exist, and dynamic NIS are continuously adapting and transforming themselves as new opportunities arise.
- NIS place great emphasis on role of the institutions both in terms of the rules of the game and the players (organizations). The success of innovation relies heavily on the 'framework conditions'—policies, laws, rules and other cultural aspects—and the basic infrastructure of the system. Indeed, a particular culture's way of working, the social values it places on innovation and entrepreneurship, funding priorities, and notion of risk often most effectively explain the difference between those who innovate and those who do not.
- Greater emphasis is placed on the pattern and intensity of interactions between the different actors within the NIS.
- Successful innovation requires both the 'supply-push' of the research community and the 'demand-pull' of the users of new knowledge. Indeed, a successful system of innovation requires a constant interaction between many organizations and individuals in both camps.
- Innovation takes place within a social system of which research and researchers form only a part of. Other essential components are the networks of actors that provide communication channels linking organizations and individuals. Such networks can be both formal and informal.

'Intermediate organizations' often prove crucial to successful innovation, particularly when their task is to find out what producers (and their end users) want, and to search through the options within the stock of existing and new knowledge to find what best meets the needs.

3.3.2 Agricultural innovation system

The origin and application of innovation systems concept in agriculture can be traced to a number of sources. These include the National Innovation System (NIS) that Freeman (1987) applied in the industrial sector of the developed economies; the multiple source of innovation model for agricultural research and technology promotion as suggested by Biggs (1989); the inadequacy of the linear model to explain the actual process of innovation in the real world; the inadequacy of the existing organizational frameworks to be all inclusive in terms of the coverage of the various actors; and the increasing demand for demonstrated developmental impacts and the expanded mandate and expectations from the R&D communities (research for development). Details of the evolution of the application of the innovation systems concept to agriculture is given in Annex 1.

A collaborative arrangement bringing together several organizations working towards technological, managerial, organizational and institutional change in agriculture can be called 'Agricultural Innovation System'. Such a system may include the traditional sources of innovations (indigenous technical knowledge); modern actors (NARIs, IARCs, advanced research institutions); private sectors including agro-industrial firms and entrepreneurs (local, national and multinationals); civil society organizations (NGOs, farmers and consumer organizations, pressure groups); and those institutions (laws, regulations, beliefs, customs and norms) that affect the process by which innovations are developed and delivered. A typical national agricultural innovation system is presented in Figure 2.



Source: World Bank (2007).

Figure 2. *National agricultural innovation system.*

As shown in Figure 2, like the NIS, a typical generic AIS incorporates a complete system of diverse agents whose interactions are conditioned by formal and informal socio-economic institutions. AIS concept focuses on the totality of actors needed to stimulate innovation and growth and emphasizes the outcomes of knowledge generation and adoption. The framework captures not only the influence of the market forces, but also the impacts of organizational learning and behavioural change, non-market institutions and public policy processes (World Bank 2007). It also highlights the importance of framework conditions and linkages to other sectors and the broader science and technology community both within and outside the country. It is also important to note that this framework explicitly integrates the value chain concept.

AIS perspective provides a means of analysing how knowledge is exchanged and how institutional and technological change occurs in a given society by examining the roles and interactions of diverse agents involved in the research, development and delivery of innovations that are directly or indirectly relevant to agricultural production and consumption. It is also important to note that the agricultural innovation system concept has a broader perspective than the concept of agricultural research system. The key differences and similarities between agricultural research systems and agricultural innovation systems are illustrated in Table 1. It is also worth noting that the transforming agricultural R&D systems in many countries have already incorporated the elements of the evolving AIS.

According to Clark (2002) the AIS concept recognized:

- That the innovation process involves not only formal scientific research organizations, but also a range of other organizations and other non-research tasks.
- The importance of linkages, making contracts, partnership alliances and conditions and the way these assist information flows.
- That innovation is essentially a social process involving interactive learning by doing and that process can lead to new possibilities and approaches inevitably leading to a diversity of organizational and institutional change. The interactions of the agents both condition and are conditioned by social and economic institutions.
- The innovation process depends on the relationships between different people and organizations. The nature of those relationships and its political economy is important.
- That knowledge production is a contextual affair, i.e. innovation is conditioned by the system of actors and institutional contexts at particular location and point in time.

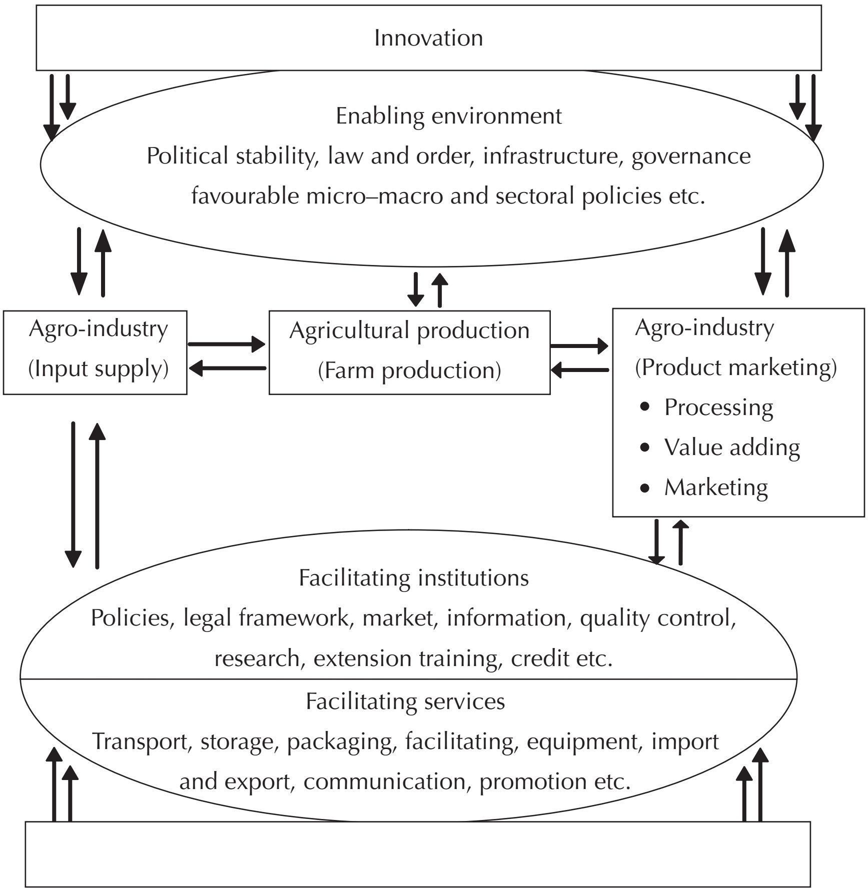
Table 1. *Similarities and differences between agricultural research systems and agricultural innovation systems*

Institutional features	Agricultural research systems	Agricultural innovation systems
Guiding agenda	Scientific	Sustainable and equitable development
Role of actors/ partners	Researchers only/fixed. Predetermined by institutional roles defined by the arrangements of the research system	Multiple, evolving and flexible. Determined by the nature of task, national institutional context and skills, and resources available
Relationships involved	Narrow, hierarchical	Diverse, consultative, interactive
Partners	Scientists in agricultural research organizations and other public agencies such as universities	Evolving coalitions of interest. Various combinations of scientists, entrepreneurs, farmers, development workers and policy actors from the public and private sectors
Selection of partners	Predetermined by institutional roles defined by the arrangement of the research system	Coalitions of interest. Determined by the nature of task, national institutional context and skills, and resources available
Research priority setting	Fixed by scientists	Consensual by stakeholders and depending on the needs of different task. Technology foresight and technology assessment approach
Work plans and activities	Fixed at the beginning of project	Flexible, iterative
Policy focus	Narrow, related to agricultural research and agriculture and food policy disconnected from other policy domains	Broad, also inclusive of trade, rural development, industry, environment, education. Integration and coordination between many policy domains
Policy process	Disconnected from stakeholders and knowledge	Integrated with stakeholders and sensitive to differing agendas
Knowledge produced	Codified, technical/scientific	All forms of codified and tacit knowledge: technical, scientific, organizational, institutional, marketing and managerial
Indicators of performance	Short-term: Scientific publications, technologies and patents Long-term: patterns of technology adoption	Short-term: Institutional development and change/new behaviours, habits and practices/links Long-term: social and economic transformation
Responsibility for achieving impact	Other agencies dedicated to extension and technology promotion	All partners: scientists and their partners in task networks
Capacity building	Trained scientists and research infrastructure	Training and infrastructure development related to a range of research and economic activities and people. Policies, practices, and institutions that encourage knowledge flows, learning and innovation among all participants

Source: Hall et al. (2005).

3.3.3 Commodity-based innovation systems

A commodity based innovation system, as shown in Figure 3, incorporates the various actors, their actions and interactions, as well as the enabling environment, facilitating institutions, and services that condition the various forms of innovation along the value chain of that commodity. This emphasizes the notion that innovation can occur anywhere along the value chain and not necessarily at the farm level; thus broadening the research agenda to incorporate both bio-physical and socio-economic research within the R4D portfolio. The concept of commodity value chain is discussed in Section 5.



Source: Anandajayasekeram et al. (2005).

Figure 3. *Typical commodity based innovation system.*

3.3.4 Intervention-based innovation system

An intervention-based innovation system can be constructed based on the nature of the problem and the context in which the innovation is applied. As we think of intervention-based innovation systems it is important to make sure that the innovation system is not confused with the innovation ecology. As noted earlier, innovation system incorporate the invention system as well as the complementary economic processes required to turn invention into innovation and subsequent diffusion and use. Innovation systems do not occur naturally, it is the problem sequence that defines a particular innovation opportunity. Hence, innovation systems are constructed for a purpose, they will change in content and patterns of interaction as the problem sequence evolves. Thus, although the innovation systems can be defined at different levels (national, sectoral, commodity and problem/intervention), the most relevant innovation system is the one that is constructed to address a particular problem. As Antonelli (2001, 2005) argued innovation systems are constructed to solve 'local' problems and they are constructed around a market problem along the value chain that shapes innovation. They are not constructed around problems that shape the growth of science and technology.

To explain the difference between generic systems and the problem centred innovation system, Metcalfe and Ramlogan (2008) made a distinction between 'innovation ecology' and a problem focused innovation system. The term innovation ecologies 'refer to a set of individuals usually working within organizations who are the repositories and generators of existing and new knowledge'. Included in this ecology are those organizations that store and retrieve information as well as those that manage the general flow of information. The principal actors are usually profit seeking firms (in the value chain), universities and other public and private specialist research organizations and knowledge based consultancies. They exhibit collectively a division of labour that is characteristics of the production of knowledge (Metcalfe and Ramlogan 2008). These ecologies are typically national in scope, with subnational degree of variation (often generic in nature), necessarily reflecting rules of law, business practice and the social and political regulation of business of the economies in which they are located (Carlsson 1997; Cooke et al. 2000). The concept of NIS, AIS, and commodity based innovation systems are generic in nature and fall under the category of innovation ecology.

Problem focused innovation systems on the other hand, are constructed to address specific problems. These systems are very specific in nature; deals with the connection between the relevant components of the ecology; and ensures that the flow of information is directed at a specific purpose. Depending upon the problem at hand there can be multiple innovation systems supported by the same innovation ecology. Moreover, since the solution of one problem typically lead to different and new problems, we would also expect that as the problem evolves the actors in the system as well as their interconnectedness will also vary. Thus, while the ecologies are more permanent, the problem focused innovation systems are transient or temporary in nature. Once a particular problem sequence is solved the associated system can be dissolved. The dynamism of an economy/value chain depends on the adaptability with which innovation systems are created, grow, stabilize and change as problem sequence evolves (Metcalfe and Ramlogan 2008, 442). A problem focused innovation system can be transboundary in nature or cut across national boundaries and may be spatially unconstrained. This problem focused, transboundary, dynamic nature of the innovation system is the most relevant one for the R&D community.

3.4 What is innovation systems perspective?

Innovation systems perspectives (ISP) implies the use of innovation lens in the design, implementation and evaluation of the activities of the various actors involved in the innovation process. ISP sees the innovative performance of an economy as depending not only on how individual institutions (firms, research institutes, universities etc.) perform in isolation, but on how they interact with each other as elements of a collective system and how they interplay with social institutions such as values, norms and legal frameworks. ISP suggests the analysis of three elements: the components of the system, principally its actors; the relationships and interactions between these components and the competencies, functions, process and results such components generate. Therefore the analytical implications of ISP are that there is a need to consider a range of activities and organizations related to research and development and how these might function collectively and the need to locate R&D planning and implementation in the context of norms and the cultural and political economy in which it takes place, i.e. the wider institutional context.

The key features of ISP include (Hall et al. 2005):

- Focuses on innovation (rather than research/technology/knowledge) as its organizing principle;
- Helps to identify the scope of the actors involved and the wider set of relationships in which innovation is embedded;
- Escapes the polarized debate between ‘demand driven’ and ‘supply push’ approaches for research for development;
- Recognizes that innovation systems are social systems, focusing on connectivity, learning as well as the dynamic nature of the process;
- Leads us to new and more flexible organizations of research and to a new type of policymaking for science, technology and innovation;
- Emphasizes that partnerships and linkages are integral part of the innovation system;
- Emphasizes that learning and the role of institutions are critical in the innovation process.

The dynamics do not depend on the agents 'expanding the frontier of knowledge' but on the innovative abilities of a large number of agents. This dynamics depends on the strength of information flows and the absorptive capacity of the individual agents of institutions and of society as a whole. The innovation processes depend on the interactions among physical, social and human capital, but mostly on the absorptive capacity of individual agents (Ekboir and Parellada 2004).

3.5 Factors contributing to successful innovation

Although the concept of 'innovation' and innovation system is relatively new for agriculture, these frameworks have been used in the industrial sector for a considerable period. A number of lessons can be drawn from these experiences.

Rothwell (1992) conducted a landmark study in the UK to identify factors that characterize successful innovations and unsuccessful innovations. The key conclusions of this study were:

- Successful innovators were seen to have a much better understanding of users' needs than did the unsuccessful.
- Successful innovators developed processes and structures to integrate development, production, and delivery activity; failures lacked such communication between these areas.
- Successful innovators performed the development work more efficiently than the failures, but not necessarily more quickly.
- Successful innovators, although typically have internal R&D capability, made more use of outside technology and scientific advice, not necessarily in general but in the specific area concerned; failures tended to have little communication with external knowledge sources.
- Success was correlated with high-quality R&D resources and effort dedicated to the project, and to the level of commitment in terms of team size; failures had fewer resources and the result was lower-quality products.
- Success was found to be linked to the status, experience, and seniority of the innovator or entrepreneur responsible for the innovation. Successful innovation champions were usually more senior and had greater authority than their counterparts in unsuccessful projects. This indicated a stronger commitment by senior management to the project.

The single most important feature is to stress that the central importance of understanding users' needs must translate into action across all functional areas. This does not only mean better market research. It also means that R&D, design, and production departments are involved with users at an early stage in the innovation process. 'R&D people and entrepreneurs tend to dismiss the point as obvious, but nevertheless continue to ignore it in practice' (Freeman 1982). Wycoff (2004) identified the top ten killers of innovations. These are summarized in Box 1.

Box 1: Top ten killers of innovation

- Not creating a culture that supports innovation
- Not getting buy-in and ownership from business unit managers
- Not having a widely understood, system-wide process
- Not allocating resources to the process
- Not tying projects to company strategy
- Not spending enough time and energy on the fuzzy front-end
- Not building sufficient diversity into the process
- Not developing criteria and metrics in advance
- Not training and coaching innovation teams
- Not having an idea management system

Source: Wycoff (2004).

Therefore, the main factors influencing the success of innovation are:

- Establishment of good internal and external communication; effective links with external sources of scientific and technological know-how; a willingness to take on external ideas.
- Treating innovation as a corporate task: effective functional integration; involving all departments in the project from its earliest stages; ability to design for 'marketability' (people who have been to the field have strong feelings on what is feasible and what is not).
- Implementing careful planning and project control procedures: committing resources to early and open screening of new projects; regular appraisal of projects.
- Efficiency in development work and high-quality production: implementing effective quality control procedures; taking advantage of up-to-date production equipment.
- Emphasis on satisfying user needs: efficient customer links: where possible, involving potential users in the development process.
- Providing good technical service to customers, including customer training where appropriate.
- The presence of certain key individuals: effective product champions
- High quality of management: dynamic, open-minded; ability to attract and retain talented managers and researchers; a commitment to the development of human capital.

It should be emphasized that innovation requires organizations to build and coordinate capabilities across all functions. There are no examples of successful innovators being focused on a single factor. Empirical evidence also supports the view that quality of management is of paramount importance since innovation is a social process. In applying the ISP to agriculture, these lessons are highly relevant, and can make a significant contribution to institutionalization.

To conclude in the words of Barnett (2008), research converts money into knowledge and innovation converts knowledge into money. Technology knowledge (which are the direct products of research) is necessary but not sufficient to create innovation. An innovation system paradigm is an attitude of mind shift from knowledge to innovation. It explicitly recognizes the importance of different set of actors contributing to innovation especially the intermediaries, and the importance of institutions (rules of the game both formal and informal) and the political economy power and incentives and the need to change the rules of the game.

4 Agricultural value chains and value chain analysis

Another concept that is gaining popularity among the agricultural research for development (AR4D) community is the concept of agricultural value chain analysis. Although the value chain approach in general has a long tradition especially in industrial production and organization, its application in international development and agriculture, has gained popularity only in the last decade (Rich et al. 2008). Value chain approaches have been used to analyse the dynamics of markets and to investigate the interactions and relationships between the chain actors. The agricultural value chain approach is utilized by many development interventions that intend to engage smallholders either individually or collectively into the production of market oriented high value crops. Concepts and analytical tools for analysing the functioning of agricultural value chains are, therefore, important to understand the impact of chain development interventions on smallholders and the rural poor. Similar to the agricultural innovation systems perspective, value chain approaches help orient agricultural development thinking more towards a systems perspective.

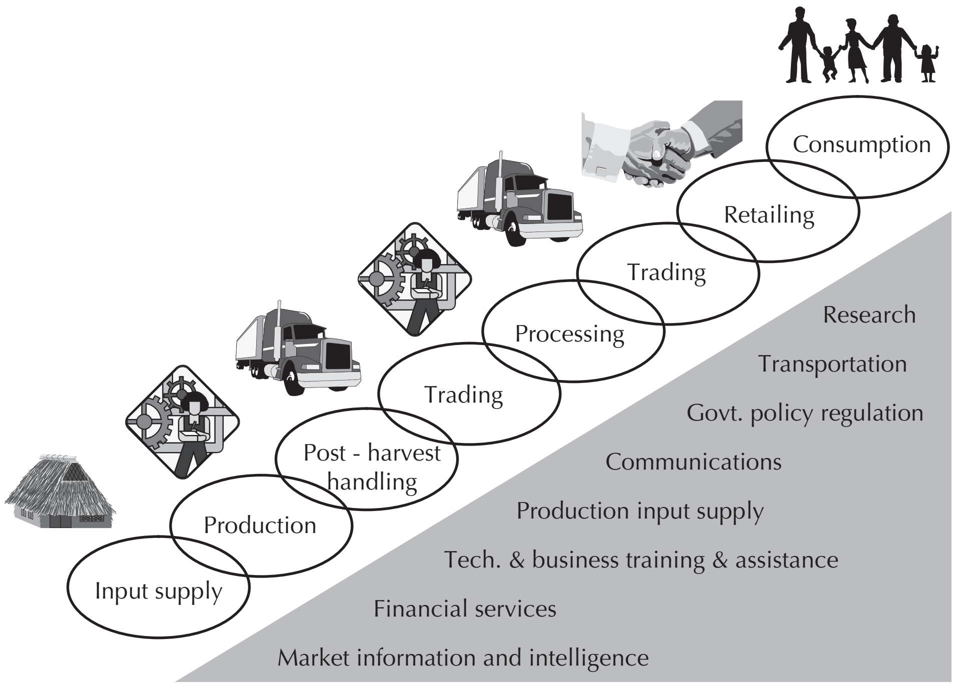
4.1 Basic concepts in agricultural value chain analysis

There are four major basic concepts in agricultural value chain analysis: value chain, stages of production, vertical coordination and business development services. Since value chains are composed of hierarchy of chain stages, the concept of stages of production is basic in value chain analysis. Closely related to the stages of production is the concept of vertical coordination. A value chain needs business support services to function. Hence, the fourth basic concept is the concept of business development services. Below, we give brief description of these basic concepts.

4.1.1 What is an agricultural value chain?

An agricultural value chain is usually defined by a particular finished product or closely related products and includes all firms and their activities engaged in input supply, production, transport, processing and marketing (or distribution) of the product or products. Kaplinsky (2000, 121) defines the value chain as 'the full range of activities which are required to bring a product or service from conception, through the intermediary phases of production, delivery to final consumers, and final disposal after use.' An agricultural value chain can, therefore, be considered as an economic unit of analysis of a particular commodity (e.g. milk) or group of commodities (e.g. dairy) that encompasses a meaningful grouping of economic activities that are linked vertically by market relationships. The emphasis is on the relationships between networks of input suppliers, producers, traders, processors and distributors (UNCTAD 2000).

The value chain concept entails the addition of value as the product progresses from input suppliers to producers to consumers. A value chain, therefore, incorporates productive transformation and value addition at each stage of the value chain. At each stage in the value chain, the product changes hands through chain actors, transaction costs are incurred, and generally some form of value is added. Value addition results from diverse activities including bulking, cleaning, grading, packaging, transporting, storing and processing. See Figure 4 for a typical agricultural value chain.



Source: Adopted from Ferris (2007).

Figure 4. *Typical agricultural value chain and associated business development services.*

Value chains encompass a set of interdependent organizations, and associated institutions, resources, actors and activities involved in input supply, production, processing, and distribution of a commodity. In other words, a value chain can be viewed as a set of actors and activities, and organizations and the rules governing those activities.

Value chains are also the conduits through which finance (revenues, credit, and working capital) move from consumers to producers; technologies are disseminated among producers, traders, processors and transporters; and information on customer demand preferences are transmitted from consumers to producers and processors and other service providers.

Value chains can be classified into two based on the governance structures: buyer-driven value chains, and producer-driven value chains (Kaplinisky and Morris 2001). Buyer-driven chains are usually labour intensive industries, and so more important in international development and agriculture, which is our focus in this paper. In such industries, buyers undertake the lead coordination activities and influence product specifications. A dairy value chain is a good example where consumer preferences and food quality and safety concerns play critical role in product handling and packaging. In producer-driven value chains which are more capital intensive, key producers in the chain, usually controlling key technologies, influence product specifications and play the lead role in coordinating the various links. Some chains may involve both producer- and buyer-driven governance (Kaplinisky and Morris 2001).

4.1.2 Stage of production

In agricultural value chain analysis, a stage of production can be referred to as any operating stage capable of producing a saleable product serving as an input to the next stage in the chain or for final consumption or use. Typical value chain linkages include input supply, production, assembly, transport, storage, processing, wholesaling, retailing, and utilization, with exportation included as a major stage for products destined for international markets. A stage of production in a value chain performs a function that makes significant contribution to the effective operation of the value chain and in the process adds value.

4.1.3 Vertical coordination

The performance of an agricultural value chain depends on how well the actors[1] in the value chain are organized and coordinated, and on how well the chain is supported by business development services (BDS). Verticality in value chains implies that conditions at one stage in the value chain are likely to be strongly influenced by conditions in other stages in the vertical chain, in direct and indirect ways, and in expected and unexpected

1. Actors in a value chain may include input suppliers, producers, itinerant collectors (small and mobile traders who visit villages and rural markets), assembly traders (also called primary wholesalers who normally buy from farmers and itinerant collectors and sell to wholesalers), wholesalers (who deal with larger volumes than collectors and assemblers and often perform important storage functions), retailers (who distribute products to consumers), and processors (firms and individuals involved in the transformation of a product). Integrated chains are coordinated chains, but not all coordinated chains are integrated chains.

ways. It should be noted that intra-chain linkages are mostly of a two-way nature. A particular stage in a value chain may affect and be affected by the stage before or after it.

Better vertical coordination in a value chain leads to better matching of supply and demand between value chain stages, resulting in efficient, low-cost exchange, maintenance of product quality (minimal spoilage, losses), productive transformation (processing, packaging) that adds value, convenience, quality and other attributes, and overall good information on supplies and prices at different levels of the value chain.

Coordination refers to the harmonization of the functions of a value chain—its conduct. The result of good coordination between the stages of a value chain may be reflected in a good match between buyer preferences and seller supplies. That is, better coordination in a value chain results in better matching of demand and supply between the chain stages, resulting in efficient and low-cost exchange, quality maintenance, and value addition. It should be noted that the co-ordination of activities by various actors within a value chain is not necessarily the same as chain governance. Coordination usually involves managing required parameters as exhibited in the bundles of activities undertaken by various actors performing specific roles in the chain. Coordination of value chains takes place at different places in the linkages to ensure consequences of interactions are as required. Coordination also requires monitoring of the outcomes, linking the discrete activities between different actors, establishing and managing the relationships between the various actors comprising the links, and organizing logistics to maintain networks.

Coordinating mechanisms are the set of institutions and arrangements used to accomplish harmonization of adjacent stages of the chain. Coordination can be done in various ways. Firms at specific key stages of a value chain (e.g. wholesalers and processors) can be coordinating agents, by handling or processing large volumes of commodity, thereby coordinating assembly, transformation and distribution. Government and non-government agencies that provide needed services, and associations of producers and processors and traders may also act as coordinating organizations. Various forms of contractual arrangements, different forms of markets (spot, futures, auction), various forms of information exchanges and vertical integration are other types of coordinating mechanisms. Uncertainty and risk, perishable nature of agricultural commodities, and increasingly stringent quality and safety standards by consumers provide strong incentives to develop effective coordinating institutions and arrangements.

The primary focus of value chain studies, therefore, is on the vertical dimension, the ways of harmonizing the vertical stages of input supply, production, processing and marketing, and the interest is on how productive, efficient and effective commodity subsystems are in the production, assembly, transformation (processing) and distribution of commodities. Coordination of the flow of physical products, information and finance within the value chain is a critical consideration, since the ultimate emphasis of value chain studies is on how well coordinated particular commodity markets are. Consideration of the vertical dimension ensures analysis of the coordination between the successive stages of the value chain. Such analysis involves analysis of the implications of the different arrangements on who bears the risk in the chain, and the structure of incentives available for the different actors. Emphasis on coordination gives value chain analysis an especially institutional flavour, since changing the basic institutions of exchange strongly influence value chain performance. The focus on vertical coordination leads the researchers to the domain of New Institutional Economics (NIE), since transaction costs, and information asymmetry, and other market imperfections (notably variable market power) influence the nature of vertical coordination (Boomgard et al. 1992, 55). The NIE is an attempt to extend neoclassical economics by explicitly incorporating institutions into economic analysis (North 1995), and provides additional insights regarding chain coordination which the neoclassical economics is unable to do.

Coordination of value chains plays an especially critical role in agricultural commodities since several factors affect vertical coordination in such value chains. Such factors include biological lag, fixed assets (once production began, price drops will not affect decision), incomplete information (especially actions of other producers), random events (weather, laws, trade policy etc.), perishablity relative to other products, storability relative to other products, and relative elasticities of supply and demand. Biological lags are pervasive in agricultural production, since production naturally requires a certain period of time. Alternative uses of fixed assets invested in agricultural production may usually be limited. Information asymmetry in agricultural markets, especially in developing countries is pervasive. Producers may not be able to co-evolve with changing market conditions if they are not informed in time. Many agricultural products are perishable and could not be stored for long.

4.1.4 Business development services (BDS)

Closely related to the concept of value chains is the concept of business development services. These are services that play supporting role to enhance the operation of the different stages of the value chain and the chain as a whole. In order for farmers to engage effectively in markets, they need to develop marketing skills and receive support from service providers who have better understanding of the markets, whether domestic or international. Local business support services are, therefore, essential for the development and efficient performance of value chains.

Business development services can be grouped into infrastructural services; production and storage services; marketing and business services; financial services; and policies and regulations. Basic infrastructural services include market place development, roads and transportation, communications, energy supply, and water supply. Production and storage services include input supply, genetic and production hardware from research, farm machinery services and supply, extension services, weather forecast and storage infrastructure. Marketing and business support services include market information services, market intelligence, technical and business training services, facilitation of linkages of producers with buyers, organization and support for collective marketing. Financial services include credit and saving services, banking services, risk insurance services, and futures markets. Policy and regulatory services include land tenure security, market and trade regulations, investment incentives, legal services, and taxation.

The roles of the business development services have hitherto been neglected. The neglect was a result of the mistaken assumption that profitable business development services will emerge as value chains develop or that the public will provide business development services where they are needed and when markets are insufficient to provide profitable niches for competitive services to develop.

4.2 The agricultural value chain analysis approach and purpose

4.2.1 What is the agricultural value chain analysis approach?

Agricultural value chain analysis can be viewed as a heuristic device or analytical tool (Kaplinisky and Morris 2001). The research can be descriptive, prescriptive and designed to provide operational guidelines to improve efficiency of vertical coordination. Agricultural value chain analysis systematically maps chain actors and their functions in production, processing, transporting and distribution and sales of a product or products. Through this mapping exercise, structural aspects of the value chain such as characteristics of actors, profit and cost structures, product flows and their destinations, and entry and exit conditions are assessed (Kaplinisky and Morris 2001). As such, value chain analysis is a descriptive construct providing a heuristic framework for the generation of data (Kaplinisky and Morris 2001). However, value chain analysis also provides an analytical structure to gain insights into the organization, operation and performance of the chain (see Annex 2 for details of the process of value chain analysis).

Agricultural value chain analysis is a dynamic approach that examines how markets and industries respond to changes in the domestic and international demand and supply for a commodity, technological change in production and marketing, and developments in organizational models, institutional arrangements or management techniques. The analysis should look at the value chain as a set of institutions and rules; as a set of activities involved in producing, processing, and distributing commodities; and as a set of actors involved in performing the value adding activities. Value chain analysis focuses on changes over time in the structure, conduct and performance of value chains, particularly in response to changes in market conditions, technologies and policies.

Agricultural value chain analysis focuses on chain governance and the power relationships which determine how value is distributed at the different levels. Through the analysis of systems and power relations at different levels, value chain analysis enables a more comprehensive modelling of the effects of interventions at different levels. Such an approach can enable a better targeting of interventions aimed at poverty reduction. Hence, value chain aims at identifying how the productivity of chain activities can be improved, either through improved technologies, organizations or institutions to better coordinate the various stages of production and distribution, and meet consumer demand.

The agricultural value chain approach accords due attention to the roles of business development services in enhancing the performance of value chains. Since final demand is the major driver of agricultural value chains, a strategy to improve the competitiveness of a value chain should consider the nature of products in relation to the type of markets where the product is sold for final usage.[2]

Value chain analysis is criticized by some as being ill-suited for activities that cut across many vertical production–distribution systems (e.g. financial system), and for being less

2. A useful framework to identify appropriate strategies is the Ansoff matrix (Ansoff 1957). In the Ansoff matrix, products and markets are classified into two: existing and new. If the objective is to increases sales of exiting products to an existing market, the strategy of market penetration is required. If the objective is to introduce new products to existing markets, the strategy of market development is required. Such a strategy may include expanding into new geographical areas, or selling to new segments of the population. If the objective is to introduce new products to existing markets, the strategy of product development is required. Such a strategy may include product differentiation through new packaging, branding, or additional processing. If the objective is to introduce new product into a new market, the strategy of diversification is required. The particular strategy selected will have implications for the different actors of the value chain.

effective in identifying within-firm constraints. However, since value chain research attempts to answer different questions than what cross-industry or firm specific studies intend to answer value chain studies are considered complementary to such studies, not substitutes (Boomgard et al. 1992).

4.2.2 Major concepts guiding agricultural value chain analysis

The agricultural value chains approach implies that four major key concepts guide agricultural value chain analysis. These are verticality and vertical coordination, effective demand, value chain governance, and leverage and impact. The concept of vertical coordination has been discussed in Section (4.1.3). In this section, we give brief description of the remaining three concepts.

4.2.2.1 Effective demand

Agricultural value chain analysis views effective demand as the force that pulls goods and services through the vertical system. Hence, value chain analyses need to understand the dynamics of how demand is changing at both domestic and international markets, and the implications for value chain organization and performance. Value chain analysis also needs to examine barriers to the transmission of information in the changing nature of demand and incentives back to producers at various levels of the value chain.

4.2.2.2 Value chain governance

Governance refers to the role of coordination and associated roles of identifying dynamic profitable opportunities and apportioning roles to key players (Kaplinsky and Morris 2001). Governance implies that interactions between firms along a value chain reflect organization, rather than randomness. The various activities in the chain, within firms and between firms, are influenced by chain governance. Value chains are characterized by repetitiveness of linkage interactions. The governance of value chains emanate from the requirement to set product, process, and logistic standards, which then influence upstream or downstream chain actors and results in activities, actors, roles and functions. Therefore, power asymmetry is central in value chain governance (Kaplinsky and Morris 2001). In other words, some key actors in the chain shoulder the responsibility to allocate roles (inter-firm division of labour) and improve functions.

Power in value chain governance can be categorized into three: setting basic rules for participation in the chain, monitoring the performance of chain actors in complying with the basic rules, and assistance to help chain actors adhere to the basic rules (Kaplinsky and Morris 2001). It must, however, be noted that some value chains may exhibit very little governance at all, or very thin governance. In most value chains, there may be multiple points of governance, involved in setting rules, monitoring performance and/ or assisting producers. The powers of governance may be vested within the chains themselves, in local communities, or in business associations.

Chain governance should also be viewed in terms of 'richness' and 'reach', i.e in terms of its depth and pervasiveness (Evans and Wurster 2000). Richness or depth of value chain governance refers to the extent to which governance affects the core activities of individual actors in the chain. Reach or pervasiveness refers to how widely the governance is applied and whether there are competing bases of power. In the real world, value chains may be subject to multiplicity of governance structures, often laying down conflicting rules to the poor producers (Kaplinsky and Morris 2001)

4.2.2.3 Leverage and impact

Value chain studies should aim to identify interventions which can have most significant impact on the value chain. In the case where large number of firms are involved it may be difficult to develop interventions to help each individual firm, since the cost of contacting each and every firm could be prohibitively high. Hence, value chain analysis seeks to identify key nodes in the chain where actions can help large number of firms at once. Such interventions are referred to as leverage. If the right leverages can be identified and implemented, small but focused interventions can result in higher impact. Leveraged interventions are likely to benefit large number of chain actors and reduce per-firm contact costs. In some value chain studies, most attention may be given to a particular industry because of its importance and the low level of knowledge available about it (Holtzman 2002).

In order to identify sources of leverage, one has to look at three key indicators: system nodes, geographic clustering or policy constraints (Haggblade and Gamser 1991). System nodes are points where large volume of product pass through the hands of only a few actors (Haggblade and Gamser 1991; Boomgard et al. 1992). Large input suppliers and output distributors often function as system nodes. Clustering offers the possibility to reach many farms in one go. Policies can be the most powerful lever, as they can likely affect a multitude of firms spread geographically and in size. Leverage interventions, therefore, involve working through large intermediary firms, delivering service to geographically clustered farms, or policy reform. Oftentimes, wholesale markets or distribution points may provide opportunities to reach a large number of small firms.

4.2.3 Purposes of value chain analysis

Value chain analysis is conducted for a variety of purposes. The primary purpose of value chain analysis, however, is to understand the reasons for inefficiencies in the chain, and identify potential leverage points for improving the performance of the chain, using both qualitative and quantitative data. In general, agricultural value chain analysis can be used to:

- understand how an agricultural value chain is organized (structure), operates (conduct) and performs (performance). Performance analysis should concern not only the current performance of the value chain, but also likely future performances, as well.
- identify leverage interventions to improve the performance of the value chain
- analyse agriculture–industry linkages
- analyse income distribution
- analyse employment issues
- assess economic and social impacts of interventions
- analyse environmental impacts of interventions
- guide collective action for marketing
- guide research priority setting
- conduct policy inventory and analysis

In sum, the concept of value chain provides a useful framework to understand the production, transformation and distribution of a commodity or group of commodities. With its emphasis on the coordination of the various stages of a value chain, value chain analysis attempts to unravel the organization and performance of a commodity system. The issues of coordination are especially important in agricultural value chains, where coordination is affected by several factors that may influence product characteristics, especially quality. The value chain framework also enables us to think about development from a systems perspective, similar to the ISP. The challenge is how to integrate value chain analysis and ISP into AR4D. In the next section, we will look at the aspects of this integration.

5 Integrating innovation systems perspective and value chain analysis in agricultural research for development

5.1 Innovation systems and value chain analysis

Improvement in productivity and competitiveness of the value chain is the litmus test for value chain innovation. Value chain innovations should, therefore, encompass the supply, demand and marketing aspects of a commodity or closely related commodities. The value chain approach to market analysis and commodity development is a convenient framework to integrate these aspects of a commodity.

The focus of value chain framework is in developing an effective way of coordinating the hierarchical stages in the value chain to meet consumer demand in an efficient manner. Effective vertical coordination of value chain stages requires partnership, actor interactions, information flow along the chain and coordination of the activities of chain actors. Hence, the competitiveness of a value chain is greatly influenced by the partnership and collaboration for innovation that can be realized by chain actors. Moreover, the development and operation of enabling and supportive business development services (e.g. market information, transport, credit) play critical role in how well the value chain responds to consumer demands. The constellation of the value chain actors and the business development services supporting it constitute the innovation system of a particular value chain.

The objectives and levels of operation of an agricultural innovation system and value chains can be similar. Value chains and an agricultural innovation system can operate at multiple levels and can pursue various objectives. Common developmental objectives of value chains and agricultural innovation system include poverty alleviation, employment generation, food security, agricultural and rural development and economic growth. Agricultural innovation systems can operate at the individual, farm, community, regional, national, or international levels (Rajalahti et al. 2008). Value chain analysis could also identify leverage interventions at similar levels. It is noteworthy, in particular, that innovations in a value chain should not be limited to improving the performance of existing chain actors, but also to expand opportunities for the poor smallholders who may otherwise be left out from benefiting as actors in the value chain. In this regard, an ideal innovation or set of innovations in a value chain is one that improves the competitiveness of the chain and ensures fair distribution of returns among chain actors.

Innovation systems help create knowledge, facilitate access to knowledge and its application to achieve economic, social and environmental gains. Information flow up and down the chain can trigger innovation in a particular stage of the chain, or on the way chain stages are organized and coordinated. In other words, innovations in a value chain can focus at a particular stage of the chain, or span across several or all of the value chain stages in terms of how they coordinate their activities. Innovation capacity of the value chain, the ability of chain actors as a group to innovate and respond to changing consumer demands, is, therefore, a sum total of the individual innovation capacity of the actors in the different stages of the value chain.

Innovation possibilities in value chains are diverse and can relate to input supply, production technology, production organization, post harvest technology and management, processing, marketing and market functions, the supply of business development services, and policy and regulatory issues. In this regard, the links in the value chain stages provide new possibilities for innovation aimed at improving the performance of the chain.

Moreover, innovations in a value chain can refer to technological, organizational or institutional aspects that have bearing on the value chain stages or on the value chain as a whole. While organizational innovations refer to the creation of entities and structures, institutional innovations refer to how the entities and structures operate. An innovation may also relate to product or process innovation (Kaplinsky and Morris 2001).

Successful dynamic improvement in value chain performance critically depends on the ability of the chain actors to acquire, absorb, disseminate and apply new technological, organizational and institutional inventions in a continuous manner. Hence, the innovation process in value chains should embrace continuous improvements in product design and quality, changes in organization and management of operations, institutional development in input supply and procurement, marketing, and associated business development services, and modifications in the production and post-harvest processes.

To conclude, both value chain analysis and innovation systems perspectives in agricultural R4D, are complementary and share a number of key features. These include: value addition (social, economic, and environmental) focus on creation of new knowledge and the novel combination of existing knowledge; emphasize on institutions (both formal and informal), emphasis on partnership, networking and interactive learning; and a need for cultivating wide range of attitude and practices among the R4D practitioners.

5.2 Integration in the design and implementation of AR4D

In order to accommodate the changing paradigms and emerging challenges, most agricultural research for development activities at present are guided by four key concepts: the innovation systems perspective, value chain, impact orientation and research for development (R4D). Very often development practitioners raise the questions whether these concepts are mutually exclusive, complementary or compete with each other and how they could be integrated into the empirical AR4D planning and implementation process. In this section we would like to demonstrate that in fact these four concepts are complementary and reinforce each other when applied in the design, implementation and evaluation of AR4D activities. They could be easily integrated into the on-going AR4D activities of the various stakeholders at different levels: global, regional, national, subregional and within a country). By necessity in this paper we will focus on this integration aspect within the research processes at the national level. However, it is important to note that the same processes (with appropriate modification) can be applied to agricultural problems at other levels (subregional, regional, and global). The relevant actors, activities and institutes may be different.

The emerging market liberalization, trade reforms and globalization are transforming national and regional economies and the farming sector. To respond to these changes there is a need to create a competitive, responsive and dynamic agriculture. This could be achieved through promoting smallholder led, market oriented agriculture, and impact oriented institutes. In this context, farming is considered as a business and the production signals are derived from the market. Improved access to market and establishing efficient value chains are critical for effective participation of the smallholder producers in the globalized economy.

A typical national agricultural innovation system is described in Figure 2. This demonstrates that implicitly enterprises and value chains are embedded in an innovation system. Market processes and innovation system are mutually embedded and it is not possible to have one without the other. Innovation systems are not alternative to the market process. Markets are part of the necessary, adaptive link between innovation and development but they are not sufficient on themselves; other instituted activities such as education, research, and service delivery all matter. The value chain concept enables us to incorporate the backward and forward linkages and realize the entire contribution of a particular sector and/or commodity to the overall economy. It also allows us to address issues beyond the farm boundaries. Innovation is perceived as a continuous learning process in which individuals/group of individuals/organizations/firms master and implement the design, production and marketing of goods and services that are new to them, although not necessarily new to their colleagues or competitors—domestic or foreign (Metcalfe and Ramlogan 2008). Innovation can occur anywhere along the value chain as shown in Figure 5 and can be of different type—technological, managerial, institutional, organizational as well as in service delivery.

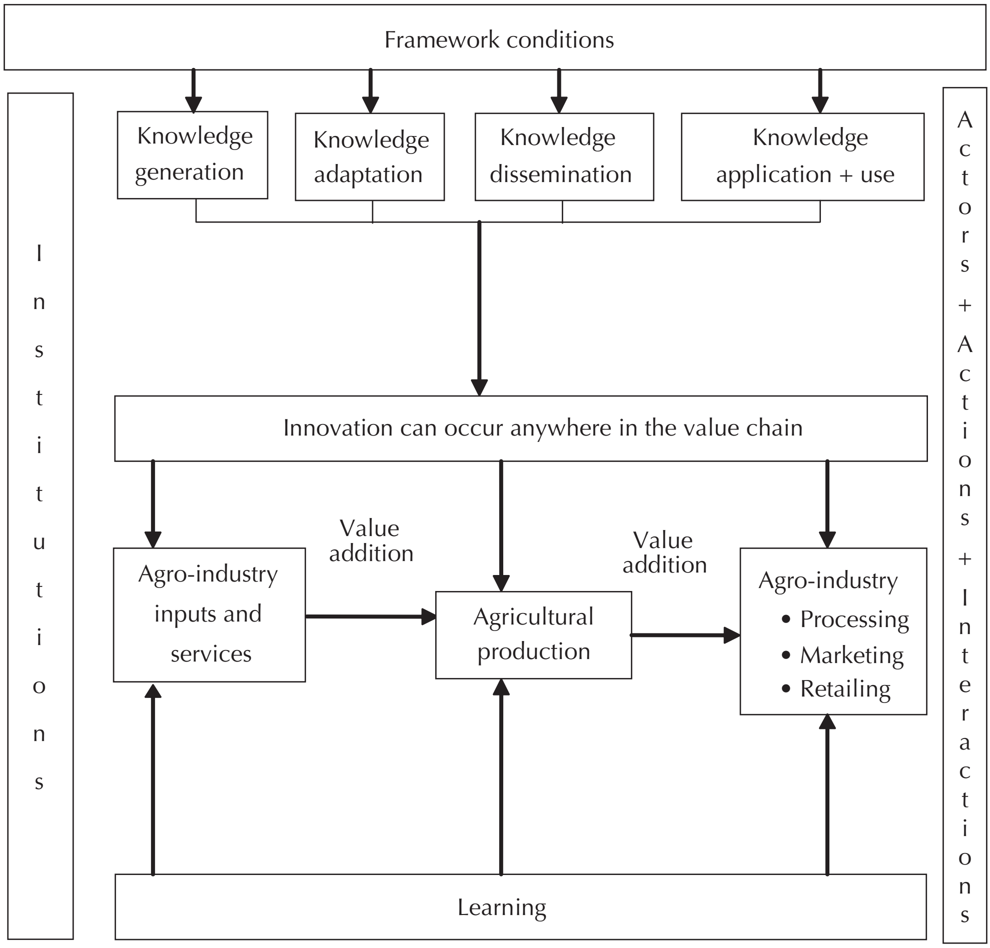


Figure 5. *Integration of value chain and innovation.*

As discussed earlier, although the innovation system can be defined and constructed at different levels (i.e. national, sectoral, commodity/enterprise and intervention) the most relevant innovation system is the problem/intervention focused innovation. Problem focused innovation system does not occur automatically; it is the problem sequence that defines a particular innovation opportunity. In practice innovation systems are constructed to solve 'local' real world problems using a value chain approach in the diagnostic process that will allow us to identify the priority problems that need to be addressed anywhere along the value chain, and an innovation system can be constructed around these problems.

The integration of innovation system concept within the agricultural research for development process, within a commodity value chain is illustrated in Figure 6. Moreover, since solving one set of problem typically lead to different and new problems, one would expect as the problem evolve so too will the actors in the system and their patterns of interactions (Metcalfe and Ramlogan 2008). Thus, as mentioned earlier, the problem/intervention focused innovation systems are transient. Once the particular problem sequence is solved the associated system can be dissolved. Depending on the nature of the problem, the relevant innovation system may be spatially unconstrained cutting across national boundaries.

In terms of integrating innovation system and value chain analysis in the AR4D, the following points need to be kept in mind:

- Use the value chain of an enterprise as the unit of analysis and focus on innovation of the entire value chain as shown in Figure 5. Please remember in terms of diagnosis the entry point is still the household livelihood system of the target group.
- Identify the most binding constraint in the value chain which inhibits the exploitation of the full potential of the value chain. Rank key component of the value chain in terms of where the grater efficiency and impact could be achieved.
- Within the high priority component (which offers the greatest opportunity) identify the various problems (options) and rank them. Please note the two stage ranking process.
- For the priority problem identified brainstorm on the potential options. Screen and identify feasible interventions. Depending on the availability of technologies and the level of confidence of replicability, the intervention may involve technology/knowledge generation, technology/knowledge adaptation and/or scaling out and up.
- Construct an 'innovation system' that is relevant to the priority intervention(s) identified. Please use the innovation lens to identify the various stakeholders who need to participate to make this intervention to become an innovation.
- Involve all the relevant key stakeholders in the planning process. Clearly identify the roles, responsibilities, resource commitment, reward sharing, rules of engagement etc.
- Implement the intervention collectively. Please remember the roles of the individual stakeholder may change as the implementation proceeds. Make sure that the various stakeholders participate in the monitoring and on-going evaluation process.
- Evaluate the performance and impact collectively.
- Document and disseminate results and plan for 'scaling up' and 'scaling out'.

To facilitate the effective integration, the capacity of all stakeholders along the value chain need to be enhanced, and the necessary policy, and institutional environments need to be created. This is a challenge focusing the R&D practitioners and policymakers. This aspect is discussed in the next Section 6.

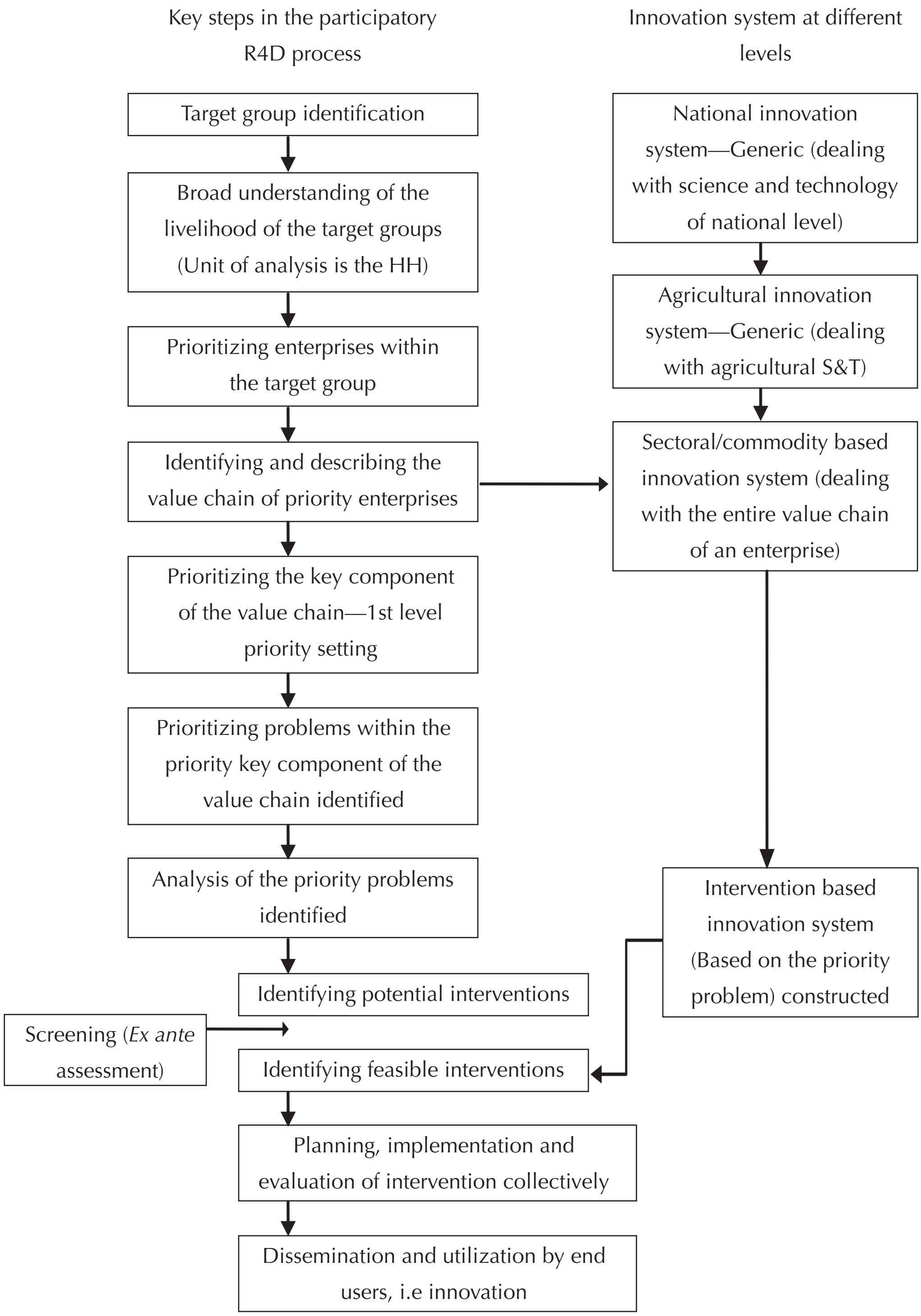


Figure 6. *Integration of research and development, value chain and innovation systems perspective.*

6 Implications and challenges

The adoption and institutionalization of the integration of the innovation systems perspective and value chain analysis in the agricultural research for development (AR4D) process has a number of implications and challenges. The next two subsections deal with the broader implications and the challenges that need to be addressed by the research and development community.

6.1 Implications

6.1.1 Implications for agricultural research for development

In understanding innovation, the distinction between information and knowledge is critical. Since only people can know, knowledge is always tacit, and for knowledge to be beneficial to societies, it must be shared considerably across individuals, so that a stimulus will elicit similar responses for cooperation to materialize. Shared knowledge is, therefore, the foundation of knowledge-based societies. Metcalfe and Ramlogan (2008, 439) succinctly put it as: 'Uneven development is a natural consequence of differential knowledge and of very different instituted ways by which societies correlate the existing knowledge and promote the growth of knowledge.'

The agricultural ISP recognizes the importance of technological, organizational and institutional inventions, but focuses on the application of inventions to achieve economic, social and environmental gains to society. Agricultural research and technology development are only part of the innovation system. The most important aspect of a successful innovation is not the creation of new inventions, but the adaptation and use of the inventions in order to realize economic, social and environmental gains. Such a shift from viewing research as the central actor to being only one important component of the innovation system carries profound implications for the organization, management and operation of the research system and how researchers operate (Rajalahti et al. 2008).

Research systems and researchers are, therefore, required to encompass a range of new activities and processes, which hitherto have been outside of their mandate.

The agricultural ISP underscores that there could be multiple sources of knowledge and inventions, including the agricultural R&D, public and private education and public institutes, other public organizations, farmers, the private sector and non-governmental organizations. Research and development organizations, as one source of inventions and new knowledge, can play an important role in promoting innovations. However, research organizations may promote innovations if they are organized in such a way that promotes actor interactions and partnerships (Rajalahti et al. 2008). Research should not isolate itself from other stakeholders. Support to public research should emphasize developing the interface with the rest of the agricultural sector, making partnerships and networks a must in the process

The ISP gives explicit attention to development outcomes, and as such it focuses on factors that facilitate or hinder sector development, beyond strengthening research capacities, which includes how research interacts with other actors to produce goods and services. In particular, the agricultural R&D system will be required to be an active player in establishing and fostering partnerships and partner interactions, and learning from networks with other actors who must be able to learn and innovate in a dynamic way so as to adopt to changing environments. Hence, the development of research capacity should encompass nurturing interactions between public research, private research, the private sector, farmers and civil society organizations.

The research systems will carry the lead responsibility of realizing the collaborative and synergistic benefits from working with others. Therefore, skills in negotiation, facilitation and conflict management will be critical for researchers. Funding and incentives to institutionalize and foster partnership and partner interactions will be needed more than ever. The ISP emphasizes the essentiality of enhancing the roles of farmers and other rural actors as the driving forces of innovations, which can, for example, be fostered through capacitating, organizing, and empowering them. Hence, the ISP requires improved research system governance that fosters partnerships. Research management should be organized in such a way that allows relevant actors to participate in strategy development, priority setting and funding, evaluation and co-learning. Consortia-based research funding to foster public–private sectors interactions is one example.

The ISP and value chain framework requires systems thinking to encompass the value addition transformations starting from production all the way to consumption. Hence, disciplinary research approaches are unlikely to fit the current demands of the ISP (World Bank 2007). Technological, organizational, and institutional aspects of improving the performance of value chains requires a multidisciplinary and multi-organizational approach to research and development. The structural organization of research organizations should reflect the multidisciplinary nature of the research.

6.1.2 Implications for innovation policy and capacity strengthening

Developing economies should be innovating economies, and creating new comparative advantages requires continuous innovation. Continuous investment in innovation capacity is, therefore, required to achieve sustained economic growth. Innovation investment can take different forms. It should be noted at the outset that there is no single innovation policy (Rajalahti et al. 2008). A set of policies is required. For example, policies meant to create conducive environment to foster innovation can remain ineffective unless accompanied by interventions to change prevailing attitudes and practices of the change agents.

Innovation investments can be categorized into two broad areas: innovation capacity and enabling environments. Innovation capacity relates to skills and capacity needed for AIS (education and training, research system, advisory services), partnerships and collaboration, and becoming a learning organization, enabling collective action, behavioural and organizational change, building innovation networks and linkages. The enabling policies for innovation relate to science and technology policy; fiscal policy; commercial and trade policy, and education policy etc. Investment in the enabling environment relates to promoting stakeholder engagement and collaboration through foresight activities, innovation platforms, adequate incentives for actors, and the development of interaction rules (related to intellectual property rights, research funding, agent roles etc.); and strengthening knowledge management capacities and collaborative arrangements that will lead to better use of available information, knowledge and technology at national, regional, and global levels, both in the public and private sector, and institutionalization of the ISP approach.

One important area of innovation investment is investment in AR4D. However, the investment priorities to foster innovation are different from the traditional investment areas. Investment in R&D to foster innovation emphasize patterns of interaction between research and other actors, alignment of policies and procedures of research organizations to the requirements of partnership and collaboration. A direct link between research and users, instead of research linked with users through an intermediary organization, such as extension, will be vital. The ivory tower mentality of research organizations should change. Moreover, there will be an increased requirement on research to be much more responsive to emerging issues and dynamic needs of sectors.

In addition to AR4D, firms are key elements of an innovation system since they make decisions of what to produce, how to produce and for whom to produce. Remember that the focus is on the transformation of smallholder agriculture into commercial orientation and commercial farming is a business undertaking. Much innovation emanates from existing firms in their effort to do things differently. Among the organizations involved in an innovation system, 'only firms have the unique responsibility to combine together the multiple kinds of knowledge required for innovation including knowledge of markets and organization' (Metcalfe and Ramlogan 2008, 440). Firms are also the key actors in the different stages of a value chain, spanning all the way from production to retail. Innovation capacity of firms, therefore, constitutes the foundation for successful innovation in value chains. Appropriate policies need to be put in place to enable firms are beneficiaries of their innovations. Such policies could relate to finance, property rights, market competitiveness, and entry and exit conditions, and others.

The changes in the emerging food systems such as rapid rise and economic concentration in supermarkets, need for quality standards; a shift towards non-price competition among supermarket chains, bio-safety issues and the development of new forms of (contractual) relationships between suppliers and buyers offer both challenges and opportunities. They can either squeeze small producers out of certain markets contributing greater poverty and inequality or can offer new sources of income and market improvement in the quality and safety of food. In order to take advantage of this emerging situation, capacity of all the stakeholders along the value chain need to be enhanced (Tschirley 2006).

6.2 Challenges

Embracing the AIS concept and value chain analysis in agricultural research for development process offers a number of opportunities as well as challenges. The paper by no means is attempting to provide answers to these challenges. The idea here is to raise these issues so that collectively the practitioners can find empirical solutions to these problems. Therefore, in this section of the paper an attempt is made to identify the key challenges, so that we could simultaneously address them while continuing AR4D activities that generate socially beneficial innovations.

- The first key challenge is limited capacity for innovation, which includes limited awareness of the concept, its application and implications for the AR4D community. Capacity building to apply the concept, as well as building sustainable capacity to build capacity remain as key challenges. The capacity for innovation occurs along one or more of four trajectories. These are product innovation, process innovation, institutional/organizational innovation, and service delivery innovation. The notion of capacity building in a system sense entails 'building up of collective capacity of networks or systems of actors interactively linked with a view to innovate'. This contrasts with the conventional thinking in which capacity development is often understood as the 'building up stocks of research infrastructure and trained scientists'. Therefore, a shift from a conventional to a systems conceptualization of capacity building requires a reorientation in our thinking. Stimulating changes in behaviour of the system and the institutions that govern the system must become the primary objective of capacity strengthening (Oyelaran-Oyeyinka 2005).
- The second key challenge is how to scale up innovations and the capacity to innovate? Both aspects, the scaling up of innovations as well as scaling up the

capacity to innovate, are equally important and deserves attention. Included in this challenge is how to develop productive and sustainable mechanisms and arrangement for AIS along the value chain.

- The third key challenge is the limited empirical evidence of the application of AIS, its utility and value addition. This challenge entails conducting credible empirical analysis, and documenting and communicating results and experiences. How can we better understand the factors that contribute to the successful and sustainable innovations? What are the central concepts, methodologies, and principles that contribute to the institutional and organizational transformation needed to promote successful innovations?
- The fourth key challenge is creating the necessary environment and incentive system to foster partnership, and reduce transaction costs of partnership and collaboration. Criteria for sustainable innovation systems are growing inter-relationship between participants in the innovation system; an intensive communication between all stakeholders; and a political and economic context favouring the agricultural innovation process. The term institutional arrangement in this context describes the mechanisms by which the various actors cooperate to promote technical and economic progress in agriculture. What are the preconditions needed to achieve this? How to assess successful partnerships, networks, and innovations? How to reward and provide incentives for the various partners in an innovation system? How do we demonstrate the utility and added value of this approach?
- The fifth challenge is how to change the mindset of actors, i.e. developing a wide set of attitudes, practices needed to foster the culture of innovation. In particular, positive attitudes toward partnership, interaction, networking and learning need to be nurtured, not only in the AR4D system, but across a wide array of actors in the sector.
- The sixth key challenge is how to institutionalize the AIS and VCA thinking which entails effective integration of the concepts and procedures with the AR4D system. There are several related key challenges: how to facilitate the creation of learning institutions? How to develop improved research governance that fosters partnership and collaboration.
- The seventh key challenge is how to institutionalize the multidisciplinary nature of research. The AISP emphasizes systems thinking to encompass the value addition transformation from production to consumption.
- The eighth key challenge is while promoting innovation and institutional arrangements that promote innovation, how to ensure that due attention is given to such factors as socio-economic equity and environmental sustainability while also generating new wealth and opportunities? What types of innovations will address poverty and how to facilitate the development of pro-poor innovation?
- The final key challenge is how to develop a coherent set of policies that foster innovation.

There is no blue print or recipe available to address these challenges. This is a long term process requiring action on a number of fronts. This type of a system pre-supposes a demand–supply relationship between users of services and service providers—a switch from a hierarchal model to a more market-like mode of cooperation, re-directing the incentives for AR4D services. Here the centralized AR4D bureaucracies are to be replaced by self responsive and responsible system. This institutional change is gradual, takes time to develop, thus calling for long term commitment.

7 Conclusion

Innovation is an essential ingredient to future success in AR4D. Every organization/ stakeholder group innovates to some degree. For some, innovation takes the form of creative and successful new products; others rely on innovative solution for achieving cost reduction and higher quality products and services; and some others see innovation as a source of competitive advantage to secure greater market. The key challenge to AR4D managers is to learn how to identify/generate commercially relevant innovation along the value chain and how to achieve it consistently.

Because of the greater emphasis on the broader developmental goal, the R4D strategies have shifted during the past decades. Currently most R4D activities are guided by four key concepts, namely, innovation system perspective, value chain orientation, research for development and impact orientation. This change in thinking recognizes that innovation takes place throughout the whole economy and not all innovations have their origin in formal R&D system, nor are all exclusively technical. Innovation can also occur anywhere along the value chain. The new perspective places more emphasis on the role of farmers, input suppliers, transporters, processors, and market actors in the innovation process. These developments clearly demonstrate that there is no uniquely best system to analyse all situations. The goal is to find the most appropriate system for the situation that one encounters; find the one that will evolve with the situation and put in place the processes that will allow one to learn and effect the future (van der Heijden 1966; Elliot 2004).

It is important to keep in mind that the innovation system perspective (ISP) does not undermine the value of research, good communication or effective extension services. These are necessary preconditions. The ISP and value chain orientation underline the need to invest not only in the research that generates this knowledge, but the quality and effectiveness of the delivery channels and the process mechanisms, and organizations that will use the knowledge once it emerges along the value chain.

The innovation system idea does not provide one generic institutional model for innovation. There is no uniform theory of innovation. Instead of postulating a defined role for different actors, it becomes necessary to assess actual condition of each case and look who among several partners may take over one or more of these functions. In this perspective, the different functions from funding to research to technology dissemination and technology adoption are still critical functions and to be performed but who performs them and how is not pre-determined. Therefore, the concept of innovation is an empirical construct. One has to observe, who is interested in a particular innovation, who participates in developing it and which rules and regulatory mechanisms are operating. As we progress from knowledge and technology generation to innovation the roles and responsibilities of the individual actors also change; a fact that need to be recognized and acknowledged.

Institutionalizing such a perspective in the AR4D system offers both opportunities and challenges. Developing, nurturing and managing a productive and sustainable institutional mechanisms and modalities of operation takes time and long term commitment by all actors involved.

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Annex 1 Evolution of the application of innovation systems concept in agriculture

As pointed out in Section 3.3.2 a number of sources have contributed to the adoption of the IS concept to agriculture. These sources include the successful application of the National Innovation System Perspective (NISP) in the industrial sector; the multiple sources of innovation model of agricultural research; the inadequacy of the linear model to explain the innovation process; the inadequate inclusiveness of the existing organizational frameworks; and the increased demand for impact.

The concept of NIS was first mentioned in the industrial innovation literature in the late 1980s. The NIS approach was pioneered by Christopher Freeman at the Science and Technology Policy Research Institute, University of Sussex, UK and Benget—Aka Lundvall at the university of Aalbarg, Denmark. Freeman (1987) defined NIS as 'the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse technologies'. Lundvall (1992) highlighted that learning and the role of institutions are critical components of NIS and emphasized the notion of diffusion of 'economically useful knowledge'.

Metcalfe (1995) expanded this concept explicitly and introduced the context of defining NIS as '… a set of institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer knowledge, skills, and artefacts, which define new technologies. The element of nationality follows not only from the domain of technology policy but from elements of shared language and culture which binds the system together, and from the national focus to other policies, laws and regulations which condition the innovation environment.' Edquist (1997) emphasized the notion of institutions and innovations and pointed out that 'authors working within the system of innovation approach (have been) centrally focused on technological innovation, and in addition, all are interested in organizational and institutional change.'

A second root is the multiple source of innovation model for agricultural research and technology promotion first proposed by Biggs (1989). In the multiple source model all technology generation and promotional activities are seen as to take place in a historically defined political, economic, agroclimatic and institutional context. In this model, major emphasis is given to the idea that innovations come from multiple sources. Not only do innovations come from those who have been designated the role of ‘researchers’ but also come from ‘practitioners’ in numerous settings throughout the research, extension, and production systems. These may include research minded farmers, innovative research practitioners, research minded administrative practitioners, innovations from NGOs, innovations from private corporations etc. Another key feature of this model is the recognition that agricultural research and technology dissemination systems contain a multitude of actors and institutions with very diverse objectives. In addition, the model focuses attention on the continuous state of disequilibrium in which agricultural research and production activities take place. Biggs (1989) argued that the multiple source model appears to better fit the practice of agricultural technology generation and dissemination.

The third major source is the inadequacy of the linear model to explain the actual process of innovation in the real world. The linear model of technical change is now widely regarded as dysfunctional. A sequence conception is inadequate because the task domain of basic and applied research (science and technology; research and extension) are seen as requiring multiple inputs and generating multiple outputs. As a result a systemic model has gained substantial favour for purposes of design, administration and analysis of innovation capabilities. Beyond empirical demonstrations on non-linearity in innovation, an interactive model is considered to be attractive because of the interdependence and potential complementarities that arise in an environment in which diverse actors (e.g. firms, universities, government agencies etc.) invest in knowledge production at comparable levels. In other words, coordination and competition are dynamics of consequence when no single actor is dominant and therefore, one must pursue an interactive model of technical change.

The fourth factor is inadequacy of the existing organizational framework to be all inclusive. Here the development practitioners began to use the concept in organizational analysis. National Agricultural Research Institutes (NARIs) framework was the first framework that emerged after the Second World War to facilitate major investments in agricultural technology to increase food production. NARIs were setup as organizational structure for agricultural research by the colonial powers to serve their interest in promoting export cash crop production. Due to its early success this institutional framework dominated for decades. However, the inadequacy of the NARIs concept to address agricultural R&D problems forced the R&D practitioners to look for alternative framework that could accommodate all public institutes involved in agricultural research, extension and education. The need to look at the various organizations undertaking agricultural research as a system gave birth to the National Systems Framework (NSF). The NSF included the National Agricultural Research Systems (NARS), the National Agricultural Extension System (NAES), and the National Agricultural Education and

Training System (NAETS). This trend of thinking continued to include the other institutions involved in agricultural R&D and resulted in a number of other concepts such as Agricultural Knowledge and Information System (AKIS), the Technology Development and Transfer system (TDT) and the Agricultural Innovation Systems (AIS).

According to Elliot (2004), the difference among the different concepts is usually found in the expression of the objective of the system which then helps analysts describe given organizations as Components of the system (C) or 'part of the Environment' of the system (E) or linked as Partner (P) as shown in Annex Table 1 below.

Annex Table 1. *Organizations as Components, Partners and Environment in the different systems*

Organizations	NARI	NARS	TDT	AKIS	AIS
Commodity, factor and thematic research institutes	C	C	C	C	C
National coordinating body or mechanism	C	C	C	C	C
Universities and faculties of agriculture	E	C	C/P	C/E	C
International agricultural research centres	E/P	E/P	E/P	E/P	C
Other international research organizations	E/P	E/P	E/P	E/P	C
Advanced research institutes	E/P	E/P	E/P	E/P	C
Universities in advanced countries	E/P	E/P	E/P	E/P	C
Private sector research (domestic and international)	E/P	E/P	E/P	E/P	C
Farmer organizations and commodity organizations	E/P	E/P	E/P	E/P	C
National extension or parastatals development organizations	E/P	E/P	C	C	C
Agricultural input and output marketing organizations	E	E/P	E	E	C
Cooperatives and farmer based intermediaries	E	E/P	E/P	C	C
Non-governmental organizations: agricultural	E	E/P	E/P	C	C
Non-governmental organizations: community based	E/P	E/P	E/P	E/P	C
Subregional, regional, global coordinating bodies	P	P	E/P	P	C
National policymaking mechanisms	E	E	E	E	C
External S&T context				E	C

Source: Elliot (2004).

It is worth noting that moving from NARIs to AIS, the goal of the system becomes broader (from research and technology to agricultural innovation); the number of organizations considered as 'components' also becomes larger and all inclusive. The issue of linkages, partnerships and interactions become more central to organizational performance. These developments also demonstrate that there is no uniquely best system. The defining features of NARS, AKIS and AIS are very well summarized and presented in Annex Table 2.

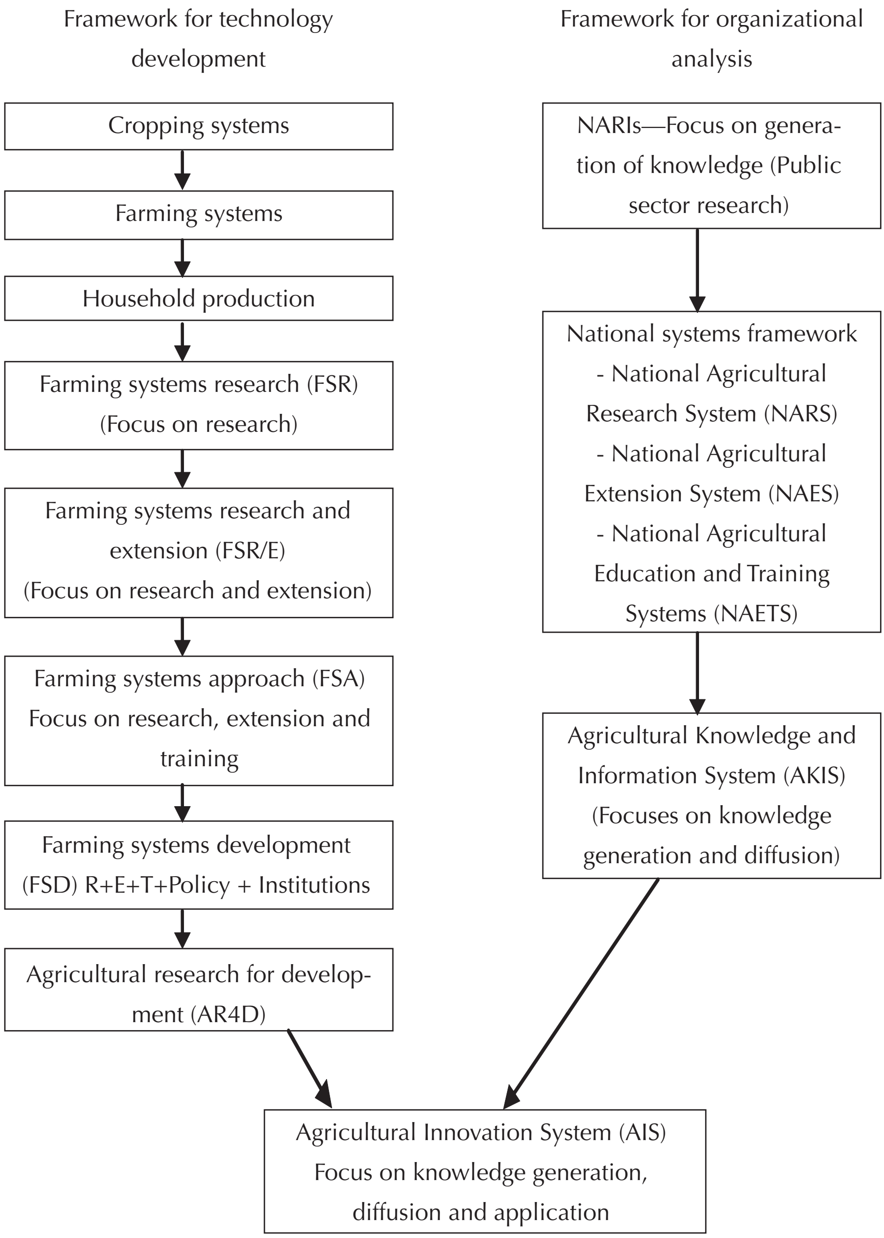
Annex Table 2. *Defining features of the NARS and AKIS frameworks in relation to agricultural innovation systems*

Defining feature	NARS	AKIS[1]	Agricultural innovation system
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 the creation, diffusion, adaptation, and use of 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 component 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

1. As defined by FAO and World Bank (2002).
Source: World Bank (2006).

While each of these 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 (Roseboom 2004).

Thus, within the agricultural sector the application of the concept evolved in two different directions—as a framework for organizational analysis and as a framework for technology development and dissemination—both leading to the innovation systems concept as shown in Annex Figure 1.



Source: Anandajayasekeram et al. (2005).

Annex Figure 1. *Evolution of systems thinking and its application in agriculture.*

In the organizational side it has started from the public agricultural research institutes to agricultural innovation system to include all organizations focusing on knowledge generation, dissemination and application. On the knowledge side, it moved from near term technology and productivity gains to innovation, therefore linking up with the broader development goals, namely, poverty alleviation, food and nutrition security, and environmental sustainability. It is interesting to note that both developments eventually resulted in the concept of innovation, a process which 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.

The fifth factor that contributed to the adoption of the IS in the agricultural sector is the many contributions expected from the R&D community to the overall economic growth and development. The concept of research for development emphasizes this expectation. When the formal research was first introduced the focus was on near term technologies and enhancing productivity. Given the unsustainable cultural practices, the expansion of agricultural activities to the marginal and hazard-prone agro-ecological zones and the concern that the agricultural practices does not adequately address the environmental externalities accompanying technological changes, led to the incorporation of environmental and ecological consideration. Currently the research is expected to contribute to the broader developmental goals such as poverty alleviation, food and nutritional security and environmental sustainability; and other MDGs. This links research directly to development and this cannot be achieved by developing technologies/ knowledge alone. Innovation is crucial for the realization of developmental impacts.

Elliot (2008) argued that the evolution towards AIS approach has three related 'schools' which are tending to come together in an AIS framework. He calls these schools as: the policy and institutional school (research in separate ministries to AIS); the natural system school (from NRM to IAR4D) and the farmer centred learning and change school. This is in line with the previous analysis. Thus, we need both a systems thinking and innovation thinking to solve complex problems and deal with the uncertainty arising from dynamic complexity of the contemporary agricultural sector (Elliot 2008).

It is worth noting that this evolutionary process is additive. It is not a totally new concept but a framework built on the existing approaches and borrowing lessons from the industrial sector. A pragmatic approach for integrating this framework into the existing system is to identify the new elements from the innovation systems framework and incorporate them into the existing system.

The main attraction of innovation systems framework stems from the fact that it recognizes innovation as a process of generating, accessing and putting knowledge into use; explicitly recognizes the interactions and knowledge flows among different actors in the process; emphasizes that institutions are vital in shaping the nature of these innovations and learning as a means of evolving new arrangements specific to local contexts (Sulaiman 2008).

To summarize the successful application of IS concept in the industrial sector, inadequacy of the existing conceptual frameworks in terms of coverage, recognition of the multiple sources of innovation, inadequacy of the linear model (research to innovation and basic research to adaptive research) to explain the process of innovation, broader mandate, and the increasing demand for demonstrated developmental impacts of the R&D system, i.e. impact orientation, have contributed to the adoption of ISP in agriculture. The ISP and value chain orientation underlined the need to invest not only in the research that generates this knowledge, but the quality and effectiveness of the delivery channels and the process mechanisms, and institutes/individuals that will use the knowledge once it emerges along the value chain.

Annex 2 The process of value chain analysis

Value chain analysis usually follows certain steps, not necessarily in a linear mode. The common steps include:

- selection of the value chain to be studied;
- defining the value chain with respect to perceived problems and the need for investigation, i.e. drawing a basic value chain map;
- identifying key areas of study; collecting data and analysis;
- identifying and evaluating leverage interventions to overcome constraints and exploit opportunities; and
- developing report and list of recommendations.

1 Selecting a value chain for analysis

Value chain for studies could be selected based on:

- unmet demand in the market
- growth potential
- potential to increase productivity
- potential to add value
- potential to increase household income and wealth
- potential for employment generation
- existence of linkages conducive to market based approach (forward/backward linkages)
- potential for positive coordination with donors and government
- participation of women
- environmental impact

2 Defining/mapping value chains

Once a value chain is identified for investigation, the value chain will need to be defined more precisely, and the need for investigation should be justified. Delineation of value chains should specify product type or types, geographical coverage, the type of actors and functions, and the different types of channels. Value chains can be defined and the need for investigation justified based on:

- review of secondary literature
- analysis of secondary data
- discussion with key informants
- discussion with knowledgeable observers
- discussion with market participants

3 Identifying key areas of investigation, collecting data and analysis

Once the value chain to be studied is adequately defined and the need for investigation justified, the key areas of study need to be identified, data collected and analysis done on the ensuing data. Although there are generic research questions that will have to be answered by a value chain analysis, such as issues of coordination, governance and performance, specific issues can be identified depending on the problem at hand. For example, the issue of income distribution may be pressing in some situations where poverty alleviation is the key objective, while in others improving the performance of the value chain may be the driving agenda. Although value chain analysis should provide a good overall overview of the chain, time and resource constraints will necessitate selecting key focal points the study team will devote more time to.

4 Identifying and evaluating leverage interventions to overcome constraints and exploit opportunities

In addition to identifying leverage points, one needs to explore the convergence between the opportunities for intervention and the available leverage points. Usually, leverage points and available interventions converge, but some times they may not (Haggblade and Gamser 1991, 16). Identification and evaluation of commercially viable solutions to overcome constraints and exploit opportunities should consider:

- existing providers
- market size and penetration
- frequency of use
- satisfaction with solution
- awareness of solution
- impact of solution on value chain

5 Develop report of analysis and list of recommendations

Value chain analysis can lead to a number of recommendations to improve the operation of the value chain. In general, the recommendation areas of value chain analysis include:

- input supply
- market options
- firm level technical assistance and training needs
- firm level business training needs
- technical innovations needs/product development
- improvements in the organization and coordination of market functions
- improvements in market information and market intelligence
- development of market institutions (grades and standards, contracts, legal framework etc.)

- establishment of market associations or producer groups/cooperatives
- improvements in market infrastructure (roads, transport, storage, processing, communication, electricity)
- improvements in financial services
- policy and regulatory issues (taxation, subsidy, laws, price control etc.)
- needs for further research for more in-depth applied research to better understand complex issues, problems and value chain inter-relationships.

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