GERRIT WILLEM GIJSBERS

Agricultural Innovation in Asia

Drivers, Paradigms and Performance

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Drivers, Paradigms and Performance

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Landbouwinnovatie in Azië:
Drijvende krachten, paradigma's en resultaten

Proefschrift

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Preface

Agriculture is back on the international agenda and in newspaper headlines. Two decades of historically low commodity prices have benefited consumers, forced producers to become more efficient, and suggested that the Malthusian threat was a thing of the past. But since 2005 food prices have started to rise rapidly and fluctuate more closely with the prices of other commodities such as oil. It is unlikely that food prices will decline to earlier low levels – and while producers benefit, consumers and especially the poor, pay the price. With growing populations and increasingly scarce natural resources (land, water, plant biodiversity) solutions have to come from smarter farming, from the use of new technologies and practices, in other words from agricultural innovation.

My interest in agricultural innovation goes back to 1976 when as a student I participated in a research project on “agrarian change” in central Mexico. I interviewed farmers about the adoption of new tools and technologies and concluded that small farmers (contrary to being “resistant to change”) were quite willing to experiment with new practices, but on their own terms. They readily accepted small (nowadays called “incremental”) innovations that they could control themselves and that fitted in their production systems, but they resisted the large-scale, modern dairy cooperatives promoted by the government.

When working at the International Service for National Agricultural Research (ISNAR) I developed an interest in the governance of agricultural research and in “institutional innovation” as it appeared that institutional issues, rather than lack of new technologies were holding back agricultural innovation. An ISNAR project on performance of agricultural research organizations in Asia provided both the need and the opportunity to advance my understanding of the roles of technologies and institutions in agricultural innovation. Around the same time I explored for the first time with Rob van Tulder the possibilities of developing this work into a thesis. Rob took me on as an external PhD candidate and I started on the long and winding road of writing a thesis.

Van Tulder (2007) discusses whether in a thesis it is appropriate to include a “thank you” line for one’s supervisor, and argues that it is – in case of exceptional support. I, as an external PhD candidate, certainly couldn’t have wished for a more supportive supervisor. Rob provided a constant stream of encouragement, inspiration and constructive criticism. Throughout the eight years or so that I have been working on this thesis and sometimes (and necessarily) got sidetracked, Rob always kept the big picture in mind and the project on course. Perhaps most importantly, Rob ensured that it was (almost) always fun to return to the writing process.

At Erasmus University Rob pioneered an institutional innovation, getting together a number of mostly and “external” PhD researchers in Friday afternoon sessions. I very much enjoyed the inspiring discussions of my own work and that of others with Myrtille Danse, Hester Duursema, Fabienne Fortanier, Margriet Glazenborg, Jolanda Hessels, Romy Kraemer, Larissa van der Lugt, Michiel Nijdam, Ron Meyer and Arjen Slangen.

Many other people have contributed directly or indirectly to the completion of this dissertation. First of all I want to thank all my colleagues at TNO's Innovation Policy group for their interest and support. A special word of thanks goes to Jos Leijten for insisting that I finish this thesis sooner rather than later. Christien Enzing has been a great colleague and I am grateful to her for sharing with me her paper about innovation networks. Frans van der Zee has always been a sharp discussion partner and his "flying geese" paper on globalization has been really helpful. I thank Maurits Butter for allowing me to use his diagram on innovation as an interactive process.

Much of the micro-level data used in this study is based on field work done in my time at ISNAR. Warren Peterson and Michèle Wilks have been outstanding colleagues, travel companions and friends. To this day I am grateful to the late Alma Torres for setting up my references database. Han Roseboom's dissertation on agricultural research investment has been quite useful for me and we have since continued to work together.

The ISNAR performance assessment project in four countries in Asia provided an opportunity to work with teams from public research organizations in a very intensive manner and to obtain an in-depth understanding of the dynamics of research organizations and the factors explaining behavior and performance. The field work undertaken as part of this project was funded by the Asian Development Bank. A word of thanks goes to Snimer Sahni our project officer at ADB for her support and keen interest in the project. Many colleagues at national agricultural research institutes in Asia have shared with me their ideas and contributed to my understanding of the problems and challenges of public agricultural research and development. In Indonesia Joko Budianto, Haryono, Joko Said, Achmad Dimiyati and Effendi Pasandaran of IAARD have supported my work and shared their ideas. In Pakistan the support of Naeem Hashmi, Iftikhar Ahmad, M. Azeem Khan and Mohamed Afzal is gratefully acknowledged. Sri Lanka colleagues who should be mentioned for their help include Tilak Wettasinghe, Chitrangani Jayasekara, and Everard Jayamanne. In Vietnam I worked closely with Nguyen Viet Hai, Le Viet Ly, Nguyen Manh Dung, Le Van Lien, Nguyen Thi Minh, and Hoang Kim Giao. None of them is of course responsible for any errors and omissions in my assessment of public agricultural research at their institutes.

In his recent running memoir Haruki Murakami observes that "[w]riting itself is mental labor, but finishing an entire book is closer to manual labor." (Murakami 2008: 79). I couldn't agree more! I would never have finished this entire book without Wilma's support, early patience and subsequent insistence that I get on with finalizing this dissertation. All I can say is: thank you so much for everything! My sons Paul and Peter have both grown up since I began writing this thesis. I want to thank them both for their friendship and for the good times together.

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Acronyms

IAARD	Indonesia Agency for Agricultural Research and Development
ABSP	Agricultural Biotechnology Support Project (USAID)
ACP	African, Caribbean and Pacific countries
ADB	Asian Development Bank
AEZ	Agro-ecological zone
AFTA	ASEAN Free Trade Area
AgGDP	Agricultural Gross Domestic Product
AIAT	Assessment Institutes for Agricultural Technology (Indonesia)
AMBIONET	Asia Maize Biotechnology Network
ASEAN	Association of Southeast Asian Nations
BIT	Bilateral Investment Treaty
CAMBIA	Center for the Application of Molecular Biotechnology in Agriculture
CGIAR	Consultative Group on International Agricultural Research
CIFOR	Center for International Forestry Research
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CSR	Corporate Social Responsibility
FAO	Food and Agriculture Organization of the United Nations
FFV	Fresh fruits and vegetables
FY	Fiscal Year / Financial Year
GDP	Gross Domestic Product
GERD	Gross Expenditure on R&D
GM	Genetically Modified
GMO	Genetically Modified Organism
GRDI	Global Retail Development Index (A.T. Kearny)
HCMC	Ho Chi Minh City
HDR	Human Development Report (UN)
HRD	Human Resource Development
HRM	Human Resource Management
IAARD	Indonesian Agency for Agricultural Research and Development
IARC	International Agricultural Research Center
IFPRI	International Food Policy Research Institute
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
ISAAA	International Service for the Acquisition of Agri-biotech Applications
ISNAR	International Service for National Agricultural Research
MFN	Most Favored Nation
MINFAL	Ministry of Food Agriculture and Lands (Pakistan)
MNE	Multinational Enterprise
Mt	Metric tons
MTA	Material Transfer Agreement
NARC	National Agricultural Research Center (Pakistan)
NARS	National Agricultural Research System

NGO	Non-governmental organization
NSI	National System of Innovation
ODA	Official Development Assistance
PARC	Pakistan Agricultural Research Council
PBS	Program for Biosafety Systems
PM&E	Planning, Monitoring and Evaluation
PRs	Pakistan Rupees
S&T	Science and Technology
SAFTA	South Asia Free Trade Area
SAI	Sustainable Agriculture Initiative
SLRs	Sri Lanka Rupees
SOE	State-owned Enterprise
TNC	Transnational Corporation
TRIPS	Trade Related Aspects of Intellectual Property Rights
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Program
USAID	United States Agency for International Development
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

1. Introduction: technical and institutional innovation in Asian agriculture

1.1 Asian agriculture: rapid growth, emerging challenges

Since the mid-1980s the agricultural sector in Asia has witnessed rapid growth in agricultural production combined with poverty reduction in rural areas. At present some traditional problems remain and important new challenges are emerging. These include disruptions as a result of rapid globalization, persistent poverty in some countries and regions, a declining resource base from which to feed a growing population, increasing environmental problems as a result of resource degradation and climate change, the changing nature of agriculture itself, which is shifting from low value food crops to higher value commodities such as fruits and vegetables, and the emergence of new actors on the scene e.g. international private sector seed and biotechnology companies.

In addition, since 2005 a long-term trend of declining real agricultural prices has reversed itself with commodity prices doubling between 2005 and 2007. Agricultural supplies were not to blame as price increases occurred at very high levels production – the year 2007 recording one of the largest agricultural productions ever. Demand for food and feed crops however is increasingly outstripping supplies, boosted by growing demand from countries such as China, India and Russia. Moreover, demand for maize (corn) and soybean has grown explosively since 2004 as a result of subsidies and utilization targets for biofuels established in the USA and the EU. A consensus was emerging that real prices for agricultural commodities would remain at very high levels for the period to 2017 (OECD-FAO 2008). The onset of the financial crisis in 2008 has since reversed this trend in part, and while the outlook is very uncertain, commodity prices will probably remain highly volatile in the coming years.

The challenges of economy, ecology, and globalization can only be met if Asian agriculture becomes more productive, while using fewer resources per unit of output. The common denominator of all these challenges is the need for Asian agriculture to become much more innovative and knowledge intensive. Herein lies a major problem: in the past, the impressive growth of Asian agriculture has mostly been achieved by expanding the area under cultivation and by using more inputs, such as fertilizer and pesticides. At present there is little scope for significant area expansion – on the contrary: much good agricultural land is lost to urbanization and industrialization. Also there are clear limits to the possibilities of using additional inputs. A new, more resource efficient, knowledge intensive and innovative Asian agriculture is needed, but progress towards it has been slow.

The traditional route has been through investment in agricultural research and development. Many developing countries have invested large sums in public agricultural research and extension, with significant assistance from international donors. Traditional public sector agricultural research systems, however, may not be well prepared to confront the challenges of a more dynamic and turbulent agriculture. The main challenges confronting public sector agricultural research are well known: decreasing public sector funding for research operations, competition from private sector, changing research markets as a result of internationalization and globalization, increased demands for popular participation in public sector decision making, greater client orientation and the need to define and target technology solutions to a wider variety of production systems and environments. In 1998 Byerlee and Alex concluded that many public agricultural research systems were suffering from weak management, a top-heavy bureaucracy, centralized decision making, and lack of incentives for innovation. They concluded that innovation is constrained not so much by lack of available technology, but rather by institutional issues and problems. Not a great deal has changed since then. Beintema and Stads (2008:1) observe that the institutional structure of Asia's agricultural research systems "…has remained relatively unchanged over the past two decades."

This study is concerned with innovation in Asian agriculture. It analyses agricultural innovation processes and the actors involved. It argues that agricultural innovation should be seen as a number of different processes, involving different actors and expressing fundamentally different views of agricultural innovation, agricultural technology, and indeed the nature of agriculture itself. Agricultural innovation, it is argued, involves a number of different techno-institutional paradigms. This study analyzes the emergence of these paradigms and the roles of key actors and driving forces involved. And it explores how different actors, innovation drivers and paradigms manifest themselves in different Asian countries. Specifically, this study addresses the following three research questions:

1. What different agricultural innovation models or paradigms have emerged, and how have these paradigms developed from the interaction of driving forces and innovation actors?
2. How do the different drivers, innovation actors, processes and paradigms perform in Asia?
3. How can agricultural innovation actors interact more effectively in networks, given the constraints imposed by different paradigms, and what policy measures can be taken to promote agricultural innovation?

The research questions are addressed in Parts I, II and III of the study respectively.

1.2 Three drivers: internationalization, technical and institutional change

1.2.1 The internationalization challenge

Agricultural research and innovation has always been an international business, but the current wave of internationalization and globalization is affecting developing country agricultural research and development in profound ways. The process of internationalization is driven by technological revolutions that lower the costs of information and communication, by trade liberalization leading to increases in international trade and foreign investment, by political changes that lead to more market friendly forms of economic organization, and by the growth of multi-national enterprises (MNEs). As a result of internationalization the rules of the game of technology acquisition and dissemination are increasingly made outside developing countries. The main question is in what ways internationalization and globalization processes affect agricultural innovation in developing countries in Asia.

Internationalization and the liberalization of markets widen the number of actors involved in national agricultural innovation processes. National and international public agricultural research and development organizations remain a major source of new knowledge and innovation. But increasingly, the use of technology embodied in purchased inputs and supplies (machinery, seeds, planting material, fertilizer, agro-chemicals) becomes more important. These inputs are mainly produced by national and international private sector companies.

While international and regional free trade agreements have resulted in markets opening up and in new technologies becoming more widely available, these have usually been targeted to larger, more commercial farmers. Also, in order to capture the benefits of new technology, intellectual property rights that govern the international acquisition of technology have been tightened considerably both in the field of patents and plant breeders' rights. Internationalization not only manifests itself through trade, but also through a dramatic increase in foreign direct investment (FDI), particularly by multinational enterprises. FDI is used both as an instrument to disseminate technologies developed in the MNE home country, and to capture benefits from R&D conducted in host countries.

Internationalization manifests itself in different forms as it includes actors from national, regional and global public and private sectors. This study traces how internationalization has affected research, development and innovation. It will also explore what strategies national innovation actors may employ to benefit from internationalization.

1.2.2 Technical change: from research to innovation

Innovation, broadly defined, involves the application of new technologies or practices in production processes. Research is a key source of new technology, but it does not by itself lead to innovation. Alternatively, innovation often takes place without a formal research effort, for example as a result of farmer experimentation. But if research is neither a necessary nor a sufficient condition for innovation, the question is open as to the most effective means to promote agricultural innovation. In the private industrial sector the decision of "make or buy" in technology is usually based on considerations of efficiency. In agriculture the public sector plays a key role in agricultural research, and the idea that (in-house) research may not necessarily be the most effective way to promote innovation is new to many organizations. The decision to shift an organization's focus from doing research to promoting innovations has major consequences for its roles, its objectives and its programs.

The idea that agricultural R&D must focus comprehensively on the processes of innovation (from invention to diffusion) and technical change has gained ground in recent years. To shed light on the question of how innovation can be promoted, an analysis of the nature of the innovative process and the sources of innovation is undertaken, highlighting the most important debates on the nature of the innovation process and the actors involved.

1.2.3 Institutional change

Institutions involve incentives, rules, regulations and laws – as well as the organizations that are responsible for their implementation or maintenance. New laws and regulations are profoundly affecting innovation in the agricultural sector worldwide. Important institutions include trade and investment regulations, intellectual and other property rights, and food quality and safety standards. Increasingly these come from international organizations such as the WTO. In the private sector supermarkets and international food companies have emerged as major players in the agricultural innovation arena by organizing global agri-food chains that are held together by a range of public and private standards for production and processing.

While international institutions are major drivers of change, national institutions in developing countries are often seen as obstacles to innovation. Unclear property rights, rigid land markets and top-heavy bureaucratic structures and procedures limit the potential for change. Public agricultural research organizations, for example, find it difficult to address an increasingly complex R&D and innovation agenda, resulting from internationalization and pressures from stakeholders to improve performance. To address these problems, new policies, structures and incentives are needed, above all to promote interaction between a broad range of agricultural innovation actors. But institutional change is difficult to achieve, mainly as a result of what North (1995) has called “institutional path dependence”, which explains why outmoded structures, rules and incentives tend to persist.

There is a close link between technical and institutional change, especially when more radical new innovations are concerned. The co-evolution of technical and institutional change forms the key to many innovation processes. The application of biotechnology innovations requires a new institutional framework dealing with intellectual property, biosafety and food safety. And the emergence of global agri-food value chains would have been impossible without information and communication technologies (ICT).

1.3 Agricultural innovation actors

Given the complexities of technical and institutional factors in agricultural innovation, how should public and private sector agricultural innovation actors respond? There is an extensive literature that addresses questions of reorganization and restructuring and the establishment of linkages and networks between organizations (e.g. Gassmann and von Zedtwitz 1999, Hall et al. 2001, Byerlee et al. 2002). New ways of steering, governing and managing organizations are being developed. New inter-organizational arrangements are devised to deal with complex problems that need the participation of a variety of actors from different organizations. These can take the form of temporary networks that address a specific problem in a project mode of operation, or they can become more permanent inter-organizational fixtures.

The increased complexity of agricultural innovation implies that there is a need to involve a larger number and different types of actors in decision making. These actors will represent a variety of different organizations, usually with partially overlapping and partially conflicting objectives and interests. The effective involvement of a variety of actors with different sources of power, influence and interests requires the development of new organizational and institutional models, structures and processes.

Traditional public sector agricultural research organizations are not well equipped to deal with these complexities and to function effectively in a situation where they no longer have a dominant position in the process of knowledge generation and dissemination. Internally, public sector organizations tend to be bureaucratic; externally they lack effective linkages with policy makers, private sector (national and international), investors and civil society. At the same time private actors continue to play a limited role in Asian agricultural innovation.

1.4 Four paradigms in Asian agricultural innovation

Technologies and institutions influence each other as they are developed, disseminated and experimented with by different actors. Technologies and institutions co-evolve and the interaction of institutional and technological changes results in specific techno-institutional paradigms. Such paradigms emerge in different eras, have fundamentally different views of the innovation process, and are dominated by different technologies, institutions, and actors.

In agricultural innovation in Asia four techno-institutional paradigms[1] can be distinguished. They originated in different time periods; they reflect different goals and objectives, involve different key actors and stakeholders, and apply different performance criteria. The four paradigms result from combining two types of actors and two types of innovation. Core innovation actors may be public or private (as discussed in detail in chapter 5), and the innovation paradigm may be predominantly technology-based or built on institutional change (as discussed in chapters 3 and 4). This produces a two-by-two matrix with four distinct innovation paradigms as presented in Figure 1.1.

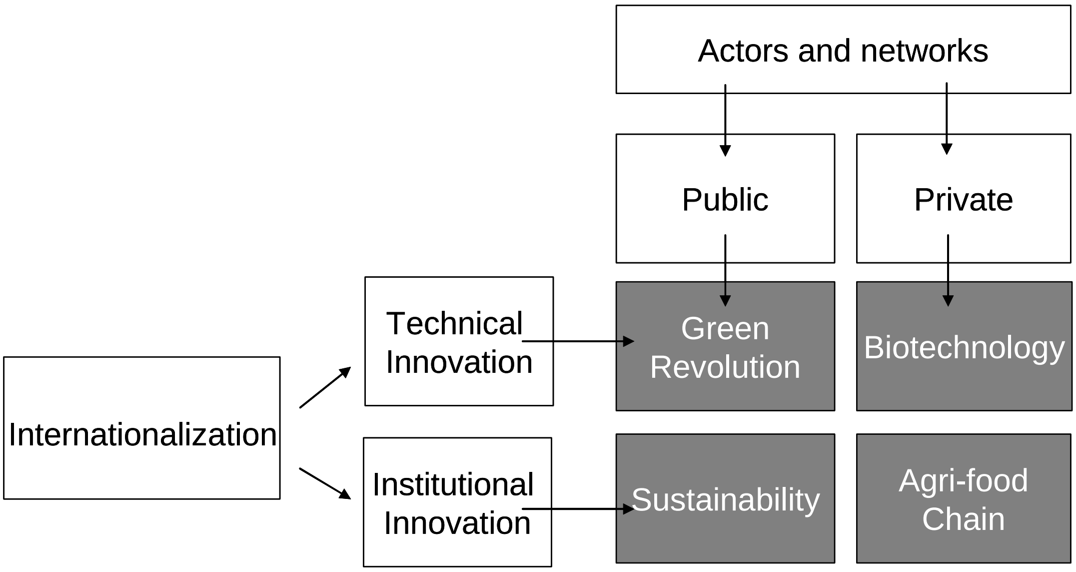
The four paradigms entail fundamentally different views about the nature of agricultural development and innovation. The paradigms arose out of four different "revolutions": the green revolution, which had the achievement of food security through the provision of new seed-fertilizer packages as it priority objective; the sustainability revolution which led to the paradigm of integrated natural resources management; the gene revolution, which is synonymous with the biotechnology paradigm, and the supermarket revolution, which is based on the rapid development of agri-food chains.

Innovation processes do not take place in a vacuum but within these specific techno-institutional paradigms. Innovation processes require the participation of a variety of organizations involved in the generation, adaptation, and dissemination of new technologies and practices as well as a regulatory framework. Different paradigms are characterized by different types of networks of innovation actors. While the paradigms emerged at different times, they co-exist and compete for resources. Asian countries have adopted the different

[1] The notion of techno-institutional paradigm is based on that of techno-economic paradigms (Freeman and Perez 1988) and related to the concept of socio-technical systems (Geels and Kemp 2007).

paradigms in varying degrees, with implications for agricultural innovation patterns and with consequences for agricultural development potential in the future.

Figure 1.1 Four innovation paradigms and their drivers



1.5 Study methodology

Studies of (agricultural) innovation often restrict the notion of innovation to R&D (and frequently to R&D inputs, because R&D outputs are hard to measure). This study takes a broader view of innovation, not only as an interactive process, but as a phenomenon that needs to be understood in terms of a number of fundamentally different paradigms.

To address the broad range of research questions introduced in the previous sections, the study employs a variety of methodologies and approaches. In part, at a theoretical and conceptual level, it may be characterized as an exploratory research study, reviewing a broad body of literature in developing the core ideas and building an analytical framework on innovation drivers, actors, and paradigms. The study can also be characterized as descriptive research when it analyses patterns of innovation in different Asian countries. The final chapters of the study are of a synthetic and prescriptive nature, assessing policy issues and recommendations.

The study relies on a variety of different information types and data. The theoretical and conceptual parts of the study rely on qualitative information and review the literature on internationalization and globalization, technical change, institutional development, innovation systems, networks, and governance.

The empirical part of the study presents the dynamics of agricultural innovation and the prevalence of innovation drivers and paradigms, based on a mix of secondary and primary data. A comparative case study approach is used, assessing patterns of innovation performance in four different Asian countries: Indonesia, Pakistan, Sri Lanka and Vietnam. These countries were selected as they represent differences between subregions and different stages of development with regard to agricultural innovation.

The empirical analysis takes an outside-in perspective, starting with an analysis of differences in agricultural sector performance and innovation systems performance, and continuing with an assessment of the performance of innovation drivers and paradigms. This goes beyond the usual assessment of R&D investment patterns and includes analysis of a broad range of secondary data from different sources: production data, trade and investment data, development indicators, science, technology and innovation indicators, governance indicators, and food market and retail investment information.

The empirical study then continues with an assessment at the micro-level of the roles and performance of a number of important public and private actors in innovation. These include the core actors in the different innovation paradigms: public agricultural research organizations and private sector companies (biotechnology and life science companies, input suppliers, and food retailers).

Information from public agricultural research organizations was obtained while working with six agricultural research organizations in four countries on issues of organizational performance and linkages from 2000-2003. Specifically, three instruments were used to obtain detailed information from these organizations. First, an organizational performance assessment instrument was developed and applied in six institutes, involving more than 20 research and management staff for each of the institutes for several days. Second, at three national level research institutes strategic plans were developed, which provided a rich source of information on organizational objectives, strengths and weaknesses. At each institute the strategic planning exercise involved two one-day workshops: one for internal and one for external stakeholders. Third, at four research institutes a linkages assessment and planning instrument was used. Its application involved a multi-stakeholder workshop at each institute involving more than 30 senior staff for several days. In addition, in Indonesia a research decentralization planning exercise provided additional information on a key policy issue in that country. Finally, a questionnaire filled in by 17 senior research managers from the four participating countries provided additional in-depth information on the key issues, challenges and constraints facing public agricultural research organizations.

Data on private sector innovation and networking activities were obtained through semi-structured interviews based on a list of questions. Private sector information was obtained from 14 companies in Indonesia, five in Sri Lanka, and five in Vietnam. Interviews with private sector companies (supported by published information) confirm the critical importance of institutional issues in innovation and the need to improve linkages in order to build effective innovation networks.

The synthetic and prescriptive part of the study brings together the information on network types, paradigms and performance in the different countries. Conclusions, policy issues and recommendations are presented for the drivers, actors and paradigms included in the analytical framework, as well as for the different countries in the analysis.

1.6 Organization of the study

The study consists of three parts. Part I is theoretical and conceptual in nature. In Part II the framework will be applied to analyze the institutional development, innovation and internationalization of Asian agriculture. Part III presents a synthesis of findings and conclusions.

Chapter 2 analyzes internationalization processes and their impact on innovation. Key developments include the opening of markets for technology, the protection of intellectual property, the increasingly important role of the international private sector investment (FDI), and the changing roles of international public sector agricultural research.

Chapter 3 reviews the technical change and innovation literature, discusses conceptual aspects and reviews the evidence on sources and processes of innovation in Asian agriculture. It analyzes the roles of different actors in innovation processes and the options for public sector agencies to provide a strategic role in the promotion of innovation.

Chapter 4 provides an overview of key topics in institutional change based on a review of the institutional development literature. It highlights the contributions of the New Public Management and New Institutional Economics schools.

The organization of innovation and particularly the role of interorganizational networks and innovation systems is the subject of Chapter 5. This chapter discusses in-depth the role of innovation systems and networks to manage and govern innovation processes at the national and sectoral levels.

Chapter 6 discusses the co-evolution of technical and institutional innovation and presents the emergence of four different paradigms in Asian agricultural innovation.

Part II of this study contains an empirical analysis of agricultural innovation in Asia and analyzes how different actors, institutions and technologies relate in unique ways to different paradigms, and how different combinations of innovation paradigms are present in different countries. The empirical analysis focuses on four countries: Indonesia, Pakistan, Sri Lanka and Vietnam. These countries were selected as they represent South Asia and Southeast Asia, and because they present different stages of development and innovation.

Chapter 7 provides an introduction to the empirical analysis of innovation patterns by discussing the concept of performance, and its measurement and evaluation at different levels of analysis.

Chapter 8 assesses performance at two levels. It starts at the most aggregate level of agricultural sector performance in Indonesia, Pakistan, Sri Lanka and Vietnam. The performance analysis is complemented by an assessment of the innovation systems of the four countries, based on published data.

Chapter 9 analyzes the performance of the three drivers of innovation: internationalization, technical change and institutional change, and assesses how the four countries have responded to internationalization, invested in R&D and adopted models of institutional change conducive to agricultural innovation.

Chapters 10 and 11 study the types of actors involved in agricultural innovation: public and private. In chapter 10 specific attention is given to the performance of agricultural R&D organizations, based on information collected at a number of research organizations. The analysis of private sector performance is based on interviews at a number of companies and on secondary data. Special attention is given to the interorganizational linkages necessary for the generation and dissemination of innovations.

Part III of the study presents a synthesis of findings, and conclusions and recommendations.

Chapter 12 elaborates on the analysis in the previous chapters by providing a synthesis of the roles of different types of innovation actors. It addresses in particular linkages between innovation actors and the presence of agricultural innovation networks in the four countries analyzed.

Chapter 13 presents the conclusions of the study, its value added, its limitations and issues for further research.

Part I Theory and Concepts

2. Internationalization and agricultural innovation

2.1 Introduction

Internationalization and globalization are issues that receive extensive coverage in the academic literature, in the media, in international fora, and on the streets of cities where governments and international organizations meet. This chapter discusses the relevance of internationalization and globalization for agricultural innovation. The main forces behind globalization and the globalization controversy are briefly analyzed (2.2). Rodrik's analysis (1999) of the importance of openness to ideas, goods and services, capital and institutions is used to identify benefits and costs (2.3). The importance of internationalization for agricultural innovation is discussed in 2.4 and elaborates on both direct and indirect ways in which internationalization affects agricultural innovation. Direct ways (2.5) include trade and foreign direct investment (FDI), and indirect mechanisms are related to international R&D (2.6) and to institutional change, notably the rise of new global institutions (particularly those related to the WTO) and the related internationalization of regulation. The indirect internationalization mechanisms are introduced in this chapter and analyzed in more detail in Chapters 3 and 4.

2.2. Internationalization and globalization: a brief overview

2.2.1 Concepts and definitions

The OECD (2005: 11) defines globalization as "… the increasing internationalisation of financial markets and of markets for goods and services. Globalisation refers above all to a dynamic and multidimensional process of economic integration whereby national resources become more and more internationally mobile while national economies become increasingly interdependent." For Stiglitz (2002: 9) it is "… the closer integration of the countries and peoples of the world which has been brought about by the enormous reduction of costs of transportation and communication, and the breaking down of artificial barriers to the flows of goods, services, capital, knowledge and (to a lesser extent) people across borders".

The concepts of globalization and internationalization refer to related sets of issues. Internationalization is the broadest term: it refers to all processes and activities between independent nations ("inter-national") or across borders. The idea of internationalization leaves the national building blocks intact. Globalization refers to global economic integration of many formerly national economies into one global economy (or companies into a truly global company), mainly through free trade and free capital mobility. Globalization in this view requires that national boundaries disappear to create a single integrated global system. "As the saying goes, to make an omelette you have to break some eggs. The disintegration of the national egg is necessary to integrate the global omelette" (Daly 1999). Views differ as to the relative importance of globalization vs. internationalization. Few actors and processes appear to be truly global in nature: most operate at bilateral or regional levels (van Tulder et al. 2001).

Internationalization is a broader concept than globalization, and covers a wide variety of activities and challenges such as bilateral investment issues, regional integration, foreign investment by firms, and international trade. Internationalization is often discussed at the level of individual actors, mainly firms, when they expand their activities across borders. Globalization (Daly 1999, Stiglitz 2002) is often related to the emergence of the new global institutions (IMF, WTO and World Bank) that redefine the rules of the game, in particular through their support for free capital mobility.

Internationalization and globalization can also be considered as the extension of networks across national boundaries (Busch and Juska 1997). Outsourcing of production, mainly to East Asia, and the emergence of global value chains, commodity chains (Gereffi 2001) and agri-food chains (Ruben et al. 2006) are examples. A network perspective on globalization helps to overcome the divide between micro approaches focusing on the firm, which see globalization as the aggregate outcome of actions by individuals, and macro political economy approaches that explain globalization in terms of capital accumulation and economic growth. A network approach to analyze globalization helps explain not only why, but also how globalization happens, for example in the emergence of global agri-food chains.

2.2.2 The globalization controversy

"Why has globalization – a force that has brought so much good – become so controversial?" (Stiglitz 2002: 4). Globalization has been the source of major conflicts from colonial times, but the modern wave of globalization has caused unprecedented resistance. After decolonization, newly independent poor countries in the South began a process of trying to "catch-up" with rich countries in the North. Many developing countries (notably in Africa and Latin America) emphasized the importance of self-reliance and of building "infant industries" behind high walls of protection to build companies that would in the long run be competitive with overseas producers. Other developing countries, notably in Asia, like South Korea, Taiwan, Singapore, Malaysia and later Indonesia, started their catching-up process in a radically different way: by competing with companies from established industrial countries exploiting advantages in competitive exchange rates, low wages and abundant supplies of labor. By the mid-1980s it had become clear that Asia's more open model was rather more successful than the import substitution model dominant in most of Latin America and Africa.

As a result, the new orthodoxy, referred to as the "Washington Consensus" – as it was promoted by the IMF and the World Bank, has stressed the importance of openness, small government, and "good governance" as the standard recipe for development. The Bretton Woods institutions have used their considerable financial weight and political power to influence policies in developing economies. This resulted in the global spread of structural adjustment policies aimed at restoring growth, introducing competition and balanced budgets. As a result of structural adjustment policies and demands for "good governance" many developing countries, have seen severe reductions in public spending and the dismantling of the welfare state. In turn, this has led to strong opposition from environmental and non-governmental organizations to the "neo-liberal" ideology of the Washington consensus.

Proponents of globalization argue on the basis of economic theory and empirical studies that it is a highly beneficial process. A global trading system leads to more efficient allocation of resources (Bigman 2002). Globalization also leads to distributional benefits as foreign direct investment in developing countries creates new employment opportunities for poor people (Glewwe 2000). Growth in and of itself (resulting from globalization) is seen as highly beneficial to the poor (Dollar and Kraay 2001). Radical opponents of globalization on the other hand see it as a conspiracy of the World Bank and the IMF to further impoverish the poorest countries in the world. They also fear an increasing uniformity and a loss of biological and cultural diversity. Globalization's "discontents" such as Stiglitz (2002) acknowledge the power of globalization to bring benefits to developing countries, but argue that the globalization agenda has been driven by rich countries that have benefited disproportionately. The benefits of globalization have been unequally distributed between rich and poor countries and notably also within poor countries (Fortanier 2008). They also point to the detrimental effects on employment and wages of workers in developed countries (the "race to the bottom"), and on working conditions and the environment both in developing countries and internationally.

Internationalization and globalization processes will most likely continue and accelerate, despite possible temporary disruptions and setbacks. The reason is that the forces behind internationalization and integration at regional and global levels are likely to persist and intensify. If the processes of internationalization and globalization do indeed continue, it is important for developing countries to understand how these processes work and to develop strategies that maximize the benefits and avoid to the maximum extent possible the detrimental effects of the internationalization.

2.2.3 Forces driving internationalization

Internationalization and globalization are not new processes. "The modern world system" (Wallerstein 1974) has been under construction for at least 500 years. Global agricultural production and trade systems started with the spice trade in the 16th Century. But the most recent wave of globalization, which started after World War II, is different from earlier phases, both quantitatively and qualitatively. It began in the 1960s, when the "old" Asian tigers (Korea, Taiwan, Hong Kong and Singapore) started to build export-oriented economies, based on their comparative advantage in labor-intensive production such as textiles and toys. At the same time companies from Europe and the USA started to outsource low-skilled production under strict licensing and Original Equipment Manufacturing (OEM) agreements (van der Zee 2006). Since then, the old tigers have moved on to highly advanced and knowledge intensive production and low skilled production moved on first to Indonesia, later to the new tigers: China, India, Vietnam, Cambodia and other countries. Both India and China have since become production and innovation powerhouses in their own right.

Globalization has manifested itself in the relocation of production, the fragmentation production systems where different parts of products can be manufactured in a number of different countries, and the integration of value chains at global level. While there is strong economic rationale underpinning globalization and internationalization, Sachs and Warner (1995) have identified a broader range of forces underlying the most recent phase of globalization:

1. Trade and exchange rate liberalization, which triggered a rapid rise in cross border trade and investment. Since the 1990s the world has witnessed a dramatic growth particularly in foreign investment. Trade and investment liberalization have been supported by the emergence of the WTO as a key player in the international arena.
2. The end of cold-war political tensions, which spurred political convergence towards market-based forms of economic organization, especially in developing countries.
3. Technological revolutions in shipping, aviation, automation, telephone and internet have widened access to information and dramatically lowered communication costs. Lower transportation cost (amongst others as a result of containerization) and improved logistics resulting from the rise of the Internet have revolutionized production and trade of many commodities.
4. Development of global media and the spread of common languages and business practices, which helped create common cultural norms and expectations.
5. The growth and proliferation of the multinational enterprise, which has emerged as a key actor in globalization of production and distribution.
6. A reluctant, but growing commitment of sovereign nation states to international decision-making on matters of global importance – especially in relation to new global challenges such as climate change (Kyoto, Bali).

Narayanan and Gulati (2002) in a review of globalization and smallholder agriculture distinguish between drivers of globalization and meta-trends that take place all over the world. These trends are independent of globalization, yet play an important role in shaping the nature of globalization. Trade liberalization is seen as the most important driver. Other drivers include the new regulatory frameworks, notably on intellectual property rights and on food safety standards. The liberalization of capital flows (FDI) is another import driver (less important in agriculture than in industrial production), which has led to the emergence of global agri-food production and marketing chains. The meta-trends that are independent of globalization, but play in important role in shaping the nature and outcome of globalization include:

- Population pressure leading to reduced farm sizes and consequences for production and the adoption of new technology
- Urbanization and rising incomes have had a profound impact on consumption patterns (increasing consumption of processed food often bought in supermarkets)
- Technological change – both in production and in post-harvest and processing technologies leading to new products and trade patterns.
- Environmental degradation which is affecting the productivity of many agricultural producers in developing countries.

In combination the drivers and the meta-trends are forming a highly complex set of issues and forces that shape modern-day agricultural production and trade.

2.2.4 The benefits of openness

Rodrik (1999), in an essay on the new global economy is asking how the new openness brought about by globalization can be made to work for developing countries. In his view openness can yield large benefits, but economic integration does not automatically produce desired results, and many claims of the benefits of openness are inflated or even false.

Countries that have done well since World War II are those that have been able to formulate a domestic investment strategy to kick-start growth, and those that have had the appropriate institutions to handle adverse external shocks; not those that have solely relied on reduced barriers to trade and capital flows. The evidence is clear: countries that have grown most rapidly since mid 1970s are those that have invested a high share of GDP and have maintained macro-economic stability. The relation between growth and openness is weak at best.

Openness, therefore, should not be an end in itself. Rodrik (1999) argues that developing nations should engage the world economy on their own terms, not on terms set by global markets or multilateral institutions. To realize the potential benefits, an outward orientation needs to be complemented by a domestic investment strategy to increase the return on private capital, and by institutions of conflict management that guarantee macro-economic stability. The benefits to openness come in the form of four types of "imports": of intermediate **goods**, of **capital,** and of **institutions** and of **ideas**.

Openness to trade in agricultural **commodities** leads to changes in production patterns in line with comparative advantage. It influences the types of commodities produced, as well as the use of technologies. Growth requires investment goods, which often cannot be produced competitively by developing countries. Increased trade in intermediate and capital goods directly stimulates innovation as these goods embody new technologies that can be readily applied. But importing readily packaged technology may go at the expense of domestic learning and innovation. These issues will be discussed in more detail in section 2.2.

In principle, the ability to import **capital** is also beneficial, but in practice it is often a mixed blessing (as witnessed for example, by the Asian financial crisis of 1997, and more recently the financial crisis of 2008). Market failures abound, caused by asymmetric information, and incompleteness of markets. These problems are especially serious with short-term capital flows. On the other hand, foreign direct investment (FDI), which is long-term in nature, is generally seen as more beneficial to developing countries (Malampally and Sauvant 1999). Since the 1980s the import of capital, in the form of FDI – particularly by multinational enterprises (MNEs) – has increased much more rapidly than trade, and has become the main driver in the globalization process (section 2.3).

Institutions play a crucial role in an open economy as trade entails arbitrage, not only in prices, but also among national institutions. Harmonization through the WTO, for example, requires the adoption of a set of institutional norms. Credibility of domestic institutions may be enhanced by adopting internationally accepted norms and will overcome traditional weaknesses in their style of governance. Uniformity and a certain discipline in institutional arrangements improve predictability and transparency. But imported institutions may also be ill-suited and even counterproductive to many developing countries – witness, for example, the new restrictions on intellectual property rights introduced under WTO. The importance for developing countries to understand the new rules of the game under WTO/TRIPS and to build "countervailing" institutions will be discussed in section 2.4.

Openness to **ideas** from abroad is a key issue as emphasized by Landes (1998) in his study of world economic history. Romer (1993) discusses two strategies in economic development: using ideas and producing ideas. Successful newly industrialized countries, such as Taiwan, produce ideas, but countries that rely on FDI and on industrial export zones merely use ideas. Internationalization may provide opportunities for learning, but the opposite is also possible. Importing new seeds, and fertilizer and machinery may increase production and stimulate innovation, but what (especially in the longer run) do these imports add to the knowledge base and the capacity of a country to innovate?

Technical change includes a number of activities: invention, innovation, imitation and diffusion (Beije 1998). The World Bank (2008:3) emphasizes that "…most developing countries lack the ability to generate innovations at the technological frontier. […] The lack of advanced technological competencies in these countries means that technological progress occurs through the adoption and adaptation of pre-existing but new-to-the-market or new-to-the-firm technologies."

In an increasingly knowledge-intensive world even using other people's ideas requires prior learning and skills related to, for example, computer use, the application of biotechnology, etc. Therefore foreign investment in local productive capacity can be an important vehicle for local technological upgrading in host countries (Narula and Zanfei 2005). Building national capacity is important to enable a country to adopt and utilize imported technologies which are increasingly knowledge intensive and of an advanced technological nature. Importing new ideas through the internationalization of R&D will be discussed in section 2.5.

The IMF (2007) has made an attempt to assess the impact of different types of globalization (trade, capital (FDI), and technological change) on developing countries, notably on income distribution. The study finds that inequality has increased in both developed and developing countries since the mid-1990s, and that technological change has made a much larger contribution to income inequality than globalization. Trade globalization has resulted in rising developing country exports, contributing to reduced income inequality. The study highlights the role of growing agricultural exports from developing countries in improving distributional outcomes. FDI, on the other hand, is found to have a negative impact on income distribution. The study concludes that the disequalizing effects of FDI and technology are working through the same underlying mechanism: an increasing demand for skilled workers.

2.3 Trade and the internationalization of agriculture

Agro-food systems in general, but particularly in Asia, have changed dramatically under the influence of internationalization and globalization processes. Four major changes stand out. First, global trade in agricultural products has increased rapidly since 1980. Table 2.1 indicates that global agricultural exports have almost trebled between 1980 and 2004. As a percentage of total exports, agricultural exports have decreased from 12 to 7%, indicating that non-agricultural exports have risen even faster. Second, Asia is witnessing the emergence of a regional agro-food system, a process driven by increased intraregional trade, industrial growth, foreign investment, and similarities in production patterns and diets (Thomson and Cowan 2000[2]. Third, the national food and agricultural policy response to globalization has varied considerably between countries: while some have started to rely on regional and global trade for foodstuffs, other countries continue to pursue national level food self sufficiency (FEER 2001). Fourth, MNEs from the Asia region, and from Europe and the USA have started to play a key role in the emerging Asian agro-food systems and in the "supermarket revolution" (Reardon et al. 2004) that since the year 2000 has had an increasingly important impact on the organization of production, technologies used, an on distribution and consumption of food products.

Table 2.1 Global agricultural exports in billion USD and as a percentage of total exports

	Total in billion USD				As a percentage of total exports			
	1979–1981	1989–1991	1999–2001	2004	1979–1981	1989–1991	1999–2001	2004
Agricultural exports	224	319	414	604	12	10	7	7

Source: FAO 2007 Table A6

Trade liberalization has led to increasingly open markets for final products and raw materials. Agricultural exports from Asia, for example, in 1999 stood at USD 179.1 billion. Growth rates have increased significantly since the 1990s. Export growth amounted to 4% p.a. over the 1990-1999 period (WTO 2000) and to 10% in the period 200-2006 (WTO 2007). But at the same time the share of agricultural products in Asia exports has declined from 9.7% to 7.1%, indicating that trade in non-agricultural products grew faster than in agricultural products.

International markets for **agricultural products** have changed rapidly. Traditionally, trade was dominated by commodities such as spices, coffee, tea, wheat, wool, and other food and fiber crops. Newer products traded globally include flowers, shrimps, wine, and tropical fruits. The demand for newer products reflects increasing affluence and sophistication in developed country consumer markets. In contrast to many traditional exports, the newer products are often perishable and require advanced logistics. Four issues are particularly important in establishing markets for non-traditional exports:

- Vertically integrated systems covering the entire value chain from production, marketing, transportation and packing to exports and retail have increased rapidly in importance and are essential to ensure delivery to the product's final destination (Swinnen and Maertens 2006). Contract farming (Da Silva 2005) and "corporate farming" approaches have become widespread in developing countries and link smallholder producers and major food corporations.

[2] According to Thompson and Cowan the increase of intraregional trade was a unique feature of Asian development and did not take place to any significant extent in Africa and Latin America.

- Competitiveness is a key issue as purchasers increasingly represent northern multinationals and supermarket chains that are used to "sourcing globally" (Thomson and Cowan 2000, Ruben et al. 2006).
- Information, in particular about markets and consumer tastes is becoming a key resource for developing countries to be successful in export markets.
- Quality control and the adoption of internationally accepted standards are becoming key factors to establish a reputation as a reliable and high-quality exporter (Hatanaka et al. 2005).

Markets **for intermediate goods, inputs and capital goods** have also become much more open than in the past. This has had an important impact on innovation in the agricultural sector as advanced equipment, agro-chemicals and germplasm usually have a higher level of built-in (embodied) technology than more traditional inputs (Roseboom 1999, Sunding and Zilberman 2001).

As mentioned before, the use of embodied technology can have a positive effect on innovation in the agricultural sector. But it may also represent a form of dependent innovation, requiring little learning. In Romer's (1993) words, the use of embodied technology would be closer to using, than to producing ideas. Using more advanced inputs and technologies, however, does require significant prior learning and knowledge. As well, in the agricultural sector few ideas or imported technologies can be used without adaptation to local conditions – some adaptive research and development is usually required.

Table 2.2 FDI inward flows and stock - World and Asia (million USD in current prices)

	FDI flows				FDI Stock			
Year	1990	1995	2000	2006	1990	1995	2000	2006
Region / Country								
World	201,594	342,592	1,411,306	1,305,852	1,779,198	2,761,189	5,810,189	11,998,838
Asia	22,642	80,008	148,333	259,434	198,053	413,679	1,069,188	1,926,949
South, East and South-East Asia	22,187	77,513	144,824	199,531	152,214	362,409	1,000,338	1,684,346
China	3,487	37,521	40,715	69,468	20,691	101,098	193,348	292,559
Hong Kong	3,275	6,213	61,924	42,892	45,073	70,952	455,469	769,029
South Asia	575	2,808	4,658	22,274	4,984	13,261	28,406	72,862
Pakistan	278	492	309	4,273	1,892	5,408	6,919	14,753
Sri Lanka	43	65	173	480	679	1,295	1,596	2,927
S.E. Asia	12,821	28,154	23,540	51,483	63,165	148,349	263,421	420,192
Indonesia	1,092	4,346	-4,550	5,556	8,855	20,564	24,780	19,056
Vietnam	180	1,780	1,289	2,315	1,650	7,150	20,596	33,451

Source: UNCTAD interactive FDI statistics, Accessed February 2008 at: http://stats.unctad.org/fdi/

2.4 Foreign direct investment

FDI and trade are two alternative, but often complementary strategies for internationalization. Since 1990 FDI has grown much more rapidly than trade (UNCTAD 2001, 2008). Table 2.2 summarizes the data globally and for Asia, for inward FDI flows and for FDI stock. Whereas trade increased at a rate of 4% p.a., FDI grew at over 20% p.a. since the 1990s. With regard to agriculture the figures on growth of FDI stock presented in table 2.3 indicate that FDI in agriculture has been increasing at about half the rate of FDI overall. Also the same UNCTAD data indicate that the share of agriculture, forestry and fisheries in the FDI stock has decreased as a percentage of the total: from 0.4% in 1990 to 0.2 % in 2004 – mainly due to the spectacular growth of FDI in manufacturing.

Table 2.3 FDI inward flows and stock World and Asia, agricultural sector billion dollars in current prices)

		FDI flows		FDI stock	
	Year	1989-1991	2002-2004	1990	2004
Region					
Developing countries		3	16	24	152
Developed counties		9	41	139	288
World		12	57	163	440

Source: UNCTAD World Investment Report 2006 Annex Table A.I.2 and A.I.4

Internationalization often begins with trading of goods and proceeds to investing overseas (Ruigrok and van Tulder, 1995). In neoclassical economic theory, FDI is seen as the transfer of capital from one country to another, i.e. from capital-abundant to capital-scarce countries. When productive capital moves in this manner it promotes production growth and welfare in the same manner as expansion of international trade in goods under scenarios of trade liberalization. In this view trade and FDI are seen as substitutes for one another.

From the perspective of the “new trade theory” first elaborated by Krugman in 1979, however, FDI is much more than a movement of capital. New trade models depart from neoclassical economics by allowing for market imperfections, strategic behavior and political economy arguments. Many of the models based on market imperfections and strategic behavior justify interventionist trade policy. FDI and trade are complements in relatively open economies and FDI is widely viewed as propelling the growth of trade in the new global economy. The main actors in the FDI game are MNEs, who are responsible for the bulk of international investment. FDI in the new trade theory involves firm level decisions to organize assets and production processes internationally, creating horizontally and vertically integrated networks and value chains. In this view FDI is an important driver of foreign trade, as it enables the emergence of global value chains. Two important questions are what are the main factors driving FDI, and whether FDI is, in fact, beneficial for developing countries.

Host country characteristics are essential in attracting FDI and in its impact on the economy. Open markets and a stable macro environment are not sufficient conditions to attract FDI, as many countries now pursue the same market-friendly policies. Increasingly, institutions and "created assets" in host countries have become important to help MNEs maintain their competitive edge. Created assets include communication and knowledge infrastructure, available technologies, and efficient markets (Mallampally and Sauvant 1999, Bevan et al. 2004).

Dunning and Narula (1996) argue that as development proceeds, created assets become more important than natural assets (that form a key element of theory of comparative advantage) in determining the levels and destinations of FDI. The created assets argument has been more consistently developed in Dunning's "OLI framework" that seeks to explain why firms engage in production abroad rather than relying on exports. The OLI framework sees FDI as determined by Ownership, Location and Internalization advantages, and the choice between an export-oriented strategy and an FDI strategy is determined by OLI advantages. The ***ownership*** advantage includes products, technologies, processes or intellectual property owned by the firm and not accessible to other companies. ***Location*** advantages relate to host country characteristics, such as low labor costs or transportation costs that make FDI more attractive than exporting. The ***internalization*** advantage is based on the concept of transaction costs and explains why a firm would prefer to establish a foreign subsidiary, rather than license its technology to an overseas company. The protection of its knowledge base, lack of trust in foreign companies, and the fear of creating future competitors all explain why firms would prefer internal over market transactions.

FDI is now generally regarded as a strongly positive factor in promoting economic development (DeRosa 1999, Fortanier 2008), although there are indications that FDI has contributed to income inequality in many developing countries (IMF 2007). Major findings from these studies are as follows:

1) FDI has raised the value of skilled labor and has contributed to economic growth and to more unequally distributed incomes.
2) FDI and host country exports are complements in both primary and secondary sectors. Foreign owned firms export more than domestic firms – because of their integration in international value chains, superior knowledge of export markets and higher standards of production.
3) New technologies are introduced in developing countries through FDI, rather than through exports from developed countries. Rather than licensing technologies to foreign firms through arms-length market transactions, MNEs like to internalize the benefits and keep control over their technologies through FDI.
4) FDI stimulates competition, productivity, and innovation by domestic firms – especially in the host country suppliers.
5) FDI has important dynamic effects in the form of spillovers to industry and effects on the broader economy.

2.5 Internationalization of regulation and the role of institutions

Internationalization of the agricultural sector entails the use of new instruments, rules and regulations that guide transactions between actors in different countries or continents. Regulation of trade and investment, of intellectual property and the use of genetic resources are three inter-related issues that have major implications for agricultural R&D.

2.5.1 Regulation of trade and investment

A key development has been the conclusion of the Uruguay Round in 1994 and the establishment of the World Trade Organization in 1995 as a new regulatory body at the global level. Further negotiations about the liberalization of trade and investment have been brought under the broader umbrella of the Doha Development Agenda since 2000.

The main instruments in trade regulation are formed by international agreements which include multilateral agreements (under GATT and WTO), the Lomé convention that regulates trade between two blocs of countries (the EU and ACP countries), regional free trade areas (NAFTA, MERCOSUR, AFTA), bilateral agreements, or unilateral actions (e.g. the granting of Most Favored Nation (MFN) status to China by the USA). The most important instrument in regulating investment are bilateral investment treaties (BITs), which are agreements between two countries to promote and regulate FDI between them (Fortanier 2008). The number of BITs, according to UNCTAD (2007) amounted to 2573 at the end of 2006, with the large majority of BITs signed since 1990 (UNCTAD 1999). The new investment frameworks have had the strongest effect on industrial production but have also affected trade, production and innovation in agriculture.

Under the influence of this new institutional framework Asian countries that were once strongly committed to self-sufficiency in food production at the national level are now opening up to trade. Under the umbrella of regional free trade agreements[3], trade in agriculture has received a major boost. An important development is the ASEAN-China Free Trade Agreement, in particular its Early Harvest Program which aims to reduce tariffs on most goods to less than 5% over the period 2004-2010. Tariffs on eight groups of agricultural products will be ended by 2010. These include live animals and plants, meat, dairy, vegetables, fruits and nuts. The effects have been dramatic: following the elimination of tariffs on fruits and vegetables in China from ASEAN countries, imports have soared by 39 % in the first half of 2004. Thai exports of fruits and vegetables to China increased by 80% and 38% respectively over the same period (Hufbauer and Wong 2005). For more sensitive agricultural commodities such as rice, maize, sugar and palm oil, quota have been replaced by tariffs and under the Early Harvest Program these are scheduled to be reduced to less than 20% by 2012.

2.5.2 Emerging intellectual property regimes

Intellectual property rights (IPR) come in different forms. In industry patents and trademarks are widely used. In the agricultural sector plant breeders' rights have traditionally been important, but patents are increasingly important in agriculture as well. Branding is growing

[3] E.g. the ASEAN Free Trade Area (AFTA) and the South Asia Free Trade Area (SAFTA).

in importance as an instrument to assure and communicate product and process quality and to create customer loyalty. Notwithstanding the importance of IPR Granstrand (2005: 284-5) observes that "…surprisingly little scholarly attention has been devoted to the study of intellectual property rights and innovation."

Property protection through patents is becoming more and more become important, first, because, with more open markets, the use of and trade in embodied technology is growing rapidly. Second, IPR in the fast growing biotechnology area follows the rules and regulations of industrial property, relying on patents to obtain temporary monopolies. Many products that used to be traded as low-technology goods or commodities now contain a higher proportion of invention in their value e.g. a soybean variety genetically modified to achieve herbicide tolerance.

With regard to the protection of intellectual property in agriculture major changes have taken place in the last two decades. New rules and regulating bodies have been established and existing organizations have tightened the rules on IPR. The World Intellectual Property Organization (WIPO) for industrial property, and the International Union for the Protection of New Varieties of Plants (UPOV), for plant breeders' rights, are important organizations in the field of IPR. But most attention goes to WTO and to the issue of Trade Related Aspects of Intellectual Property Rights (TRIPS). The reason is that despite its modest sounding name, the TRIPS agreement represents a major departure from earlier international coordination activities related to the protection of intellectual property rights (Byström and Einarsson 2001).

In the 1980s, during the Uruguay round of negotiations that led to the establishment of WTO, IPR issues were to be included only in so far as they related to trade in counterfeit goods (essentially limited to trademarks and copy-rights). But soon, developed countries started to push for broadening the scope of IPR and for the development of binding standards[4]. At first, developing countries refused to enter into such negotiations, but under great pressure from developed countries, and most reluctantly, they finally had to accept much stronger protection of IPR in the draft agreement (the so-called "Dunkel draft") that was presented to the GATT membership in 1991 (DeRosa 1992). Developing countries have had little opportunity to influence the negotiations because of their limited resources and lack of experience with IPR issues.

TRIPS requires stronger IPR legislation in most developing countries. The basic principle of TRIPS is that no field of technology can be excluded from patentability, unless this is explicitly allowed. Specifically, TRIPS represents a departure from earlier international IPR coordination in three major ways. First, under TRIPS, WTO members must provide most of the existing types of IPR protection. Earlier, countries were not obliged to offer intellectual property protection. The property rights to be provided include patents, copyrights, trademarks, industrial designs and layouts, and geographical indications. There are only two exceptions: utility models and plant breeders' rights (if patents are not provided for plants,

[4] In the process the IPR negotiating arena was essentially moved from the World Intellectual Property Organization (WIPO) to WTO.

members must ensure that “an effective *sui generis* system” is in place). Second, TRIPS specifies in great detail the substantive content of *national* IPR legislation, including for example scope of coverage, duration of protection, and mechanisms of enforcement. Third, TRIPS brings national IPR legislation under the coverage of WTO dispute settlement procedures. This may well lead to situations where non-compliance in IPR issues results in retaliation in other areas of international trade.

While TRIPS represents no major changes for most developed countries, it does have major implications for most developing countries. Amongst others, many developing countries have to:

- Phase out process patents, used in the pharmaceuticals sector, notably in India, to produce cheaper medicines;
- Discontinue present compulsory licensing practices;
- Establish either a patent or a plant breeders right system for plant varieties;
- Invest significant resources in the development of infrastructure and capacity to implement TRIPS through national legislation;
- Establish the capacity to enforce legislation.

TRIPS follows the established rationale for IPR, namely that a balance between private profit and public interest needs to be achieved to promote economic growth through the development and adoption of new technologies. But the relationship between strengthened IPR protection and economic development is far from clear. Correa (2000) reviews the evidence on the impacts of IPR on different development related areas such as economic welfare, FDI, transfer of technology, and domestic innovation in developing countries. On the basis of studies on the overall impact of IPR on economic welfare, reviewed by Correa (200), no clear picture emerges. Larger and more industrially developed countries appear to be best positioned to benefit from IPR. Lall (2003) argues that the application of uniformly strong IPR regimes in developing countries with very different technological capabilities and institutional structures will produce very different costs and benefits for those countries. Byström and Einarsson (2001) in a report for the Swedish International Development Agency (SIDA), conclude that imposing a minimum standard of IPR protection, as is mandatory under the TRIPS agreement, does not benefit developing countries. Rather, developing countries would be likely to benefit from the same strategy adopted by developed countries in earlier stages of industrial development: a flexible approach that gradually builds IPR systems, adapted to national situations. But this is precisely what TRIPS does not allow. In addition, the costs for developing countries of implementing TRIPS are likely to be very significant. For developed countries, on the other hand, TRIPS is likely to have significant benefits (because of strengthened protection) and little costs, as the necessary legal and institutional infrastructure is already in place.

With regard to FDI, the evidence is clouded by methodological issues, the most important of which is the fact that other factors besides the IPR regime play an important role in determining the level of inward FDI to developing countries. The picture is further complicated by the fact that there are a large number of different types of FDI (sectors) as well as different types of IPR. On the whole, therefore, the evidence on the FDI/IPR relationship is very inconclusive. Primo Braga and Fink (1998: 181) found that "…there is growing evidence that IPRs affect FDI decisions around the world…", and that countries with stronger IPR regimes will be better placed to attract FDI. Nunnenkamp and Spatz (2003) confirm this and find that IPR not only helps in attracting FDI, but that it also leads to higher quality FDI, defined as FDI involving advanced technologies.

Transfer of technology is an important way for developing countries to advance in their economic development process. As in the case of FDI, Correa (2000) finds that the evidence of IPR on technology transfer is limited. Arguably, IPR protection forms a precondition for innovating companies to license their technology. But at the same time, stronger IPR protection may entail higher cost for royalties and other payments. Correa observes an increased reluctance in innovative firms to transfer technology through licenses. Often, firms will seek additional protection through packaging the licensed technology with service contracts and technical assistance agreements. But, increasingly firms are afraid that licensing technologies may create global competitors and they would rather take the route of FDI.

The impact of IPR protection on domestic innovation in developing countries remains a matter of significant controversy. In general, access to scientific knowledge is becoming more complex in a time of privatization and globalization (Byerlee and Fischer 2002). One view (Correa 2000, Byström and Einarsson 2001) is that developing countries have little to gain from strengthened IPRs (as they conduct little R&D) and a lot to loose as MNEs from the North who hold large patent portfolios benefit from strengthened IPRs. While developing countries do little world class R&D, they rely mainly on new-to-the-market and new-to-the-firm innovations (World Bank 2008). Chen and Puttitanun (2005) argue therefore, that in a trajectory which starts with developing country firms imitating products and processes and proceeds to more genuine forms of domestic innovation, there is a case for improving the protection of IPR in developing countries. Their empirical analysis of 64 developing countries, covering the 1975-2000 period, shows that innovation in developing countries increases with the protection of IPR and that there is a U-shaped relationship between IPRs and economic development with IPR levels declining during the "imitation phase" and increasing as domestic innovation picks up. More generally, Chen and Puttitanun (2005) argue that IPRs should not be seen as a zero-sum game between developing and developed countries and that there is a range of common interest between the North and the South on promoting IPRs in developing countries. There appear to be optimal levels of IPR for developing countries at different stages of development. These are, however, inconsistent with the one-size-fits all model imposed by TRIPS.

2.5.3 Access to genetic resources

There is major controversy over the issue of genetic resources that focuses on two related issues: the loss of biodiversity, and the valuation and ownership of genetic resources. Genetic resources were once considered to be mankind's common heritage, but increasingly (if sometimes mistakenly) countries of origin of plant and animal species have started to see genetic resources as a source of national pride and potential revenue. In parallel to modern varieties that are protected by plant breeders' rights, traditional varieties ("landraces") are no longer seen as a public good, but as a resource that has been developed over the centuries by communities of rural people. Regulation of ownership of plant genetic resources is covered under the International Undertaking on Plant Genetic Resources for Food and Agriculture of the FAO. The International Undertaking aims to "ensure that plant genetic resources of economic and/or social interest, particularly for agriculture, will be explored, preserved, evaluated and made available for plant breeding and scientific purposes"[5]. The International Undertaking has agreed that plant breeder's rights, as provided for under UPOV, are "not inconsistent" with the Undertaking, but added in 1989 that farmers rights need to be recognized and subsequently recognizing the sovereign right of nations over their genetic resources.

An important instrument in governing and regulating access to genetic resources is formed by Material Transfer Agreements (MTAs). MTAs are (private) contracts that govern the transfer of tangible research materials between two organizations (usually between universities, research institutes, or private companies). An MTA specifies the rights of the provider and the recipient of the research material with regard to the material itself and derivatives thereof (Rodriguez 2008). MTAs originated in biotechnology where they govern the exchange of cell lines, plasmids, constructs etc., but their use has been extended to other types of research products such as software. MTAs are a departure from the time when the exchange of research materials such as plant varieties (seeds, cuttings) was a matter of course between researchers. MTAs restrict the open exchange of research materials and regulate for what purpose they may be used and by whom. There is thus a risk that MTAs may be detrimental to innovation, a situation in which there is a case for public policies (Rodriguez 2008).

2.6 The internationalization of R&D in private and public sectors

Openness to ideas as described by Rodrik (1999) is perhaps the most important strategy for developing countries to benefit from investments made in the production of knowledge and technologies in developed countries.

The importance of science and technology for development was taken for granted in the 1970s and 1980s. But since the 1990s more attention has been given to actual and imagined negative side effects of new technologies on developing countries as witnessed by the debates on biotechnology, biosafety, "biopiracy" and the "digital divide". But in recent years, probably as a result of dramatic technology-led growth in developed countries and in a number of developing countries such as China, India, and Brazil, there is renewed awareness that the technology gap between developed and developing countries is wider than ever, and that developing countries need policy instruments to promote science and technology for development (UNDP 2001, Juma et al. 2001, World Bank 2007).

Private and public sectors have very different characteristics if one compares the size, location and organization of activities. Different trends can be observed with respect to all of these. This introductory section presents some key figures on public and private sector research. The following sections discuss in some more detail the main trends, including a few words on the international non-profit sector, which plays a minor role with regards to

[5] (http://www.fao.org/WAICENT/FAOINFO/AGRICULT/cgrfa/IU.htm) accessed February 2008

agricultural research and development. On a global level, R&D is highly concentrated with almost 80% of estimated capacity located in the developed economies: USD 645 billion out of a global total of USD 830 billion (table 2.4). The key private actors in R&D are MNEs with a small number of them responsible for the lion's share of expenditure (Van Tulder et al. 2001). The 700 largest firms (almost all of them MNEs) were responsible for 45% of global R&D and 69% of business R&D (UNCTAD 2005).

By contrast, agricultural research is much less concentrated in developed economies with almost 40% of total research capacity installed in developing countries. When looking at public agricultural research, well over 50% is taking place in developing countries – USD 12.8 billion in developing countries vs. USD 10.2 billion in developed economies (table 2.4). This reflects the fact that agricultural production is spread widely across the globe and that most governments in developing countries have established public sector agricultural research and knowledge infrastructures.

Table 2.4 Developing and developed country total and agricultural R&D expenditures (2000-2002) in PPP dollars

	R&D Exp. (Billion USD)	% of World R&D Exp.	R&D Exp. as a % of GDP	R&D Exp. per inhabitant (USD)	Agricultural R&D Exp. (Billion USD)	% of world agricultural R&D Exp.	Public Agricultural R&D Exp. (Billion USD)	% of world public agricultural R&D Exp.
Developed countries	645.8	77.8	2.3	540.4	22.8	62.5	10.2	44
Developing countries	184.1	22.2	1.1	43.5	13.7	37.5	12.8	56
World	829.9	100.0	1.7	134.4	36.5	100.0	23.0	100

Sources : UNESCO 2005, Pardey et al. 2006
Note: UNESCO figures are for 2002, figures from Pardey et al. for 2000

2.6.1 International private agricultural R&D

Private sector agricultural R&D is mostly conducted as part of agro-industrial research, and includes plant breeding, agrochemicals research, machinery and equipment, and biotechnology. The internationalization of industrial R&D has increased significantly since 1990 (Niosi 1999). The four most significant developments include (Niosi 1999):

1. Changes in the nature and number of the most important actors. Major differences between industries can be noted with respect to the internationalization of R&D, with pharmaceutical drugs and medicines at the forefront, followed by other industries including food and beverages. There is consensus in the literature that large multinational firms, mainly through FDI, are the drivers of internationalization of innovation activities (Gerybadze and Reger

1999), and that international innovation is increasingly determined by a few very large actors in dominant positions (van Tulder et al. 2001).

2. Changes in the rationale and objectives of internationalization. With regard to the rationale for internationalization, theoretical approaches have moved from emphasizing technology transfer to organizational learning as the main driving force. Under the influential "product life cycle" model, the rationale for internationalization was that technology generated in the home country of the multinational enterprise could be subsequently transferred to subsidiaries in other countries, where it would be adapted for use in local markets. This involved a technology transfer process from high technology to lower technology countries.

Later on, it was found that the picture was more complex than provided for by a simple technology transfer model. Different companies from large and small countries were found to structure their international networks in different ways and showed that there were continuous pressures for centralization as well as towards decentralization of R&D. "Large corporations organized several types of decentralized federations of laboratories with different missions, resources and coordination patterns" (Niosi 1999).

In the 1990s explicit attention was given to the specific strategies for product development and innovation in a centralized-decentralized MNE. It was noted in particular that MNEs were increasingly establishing R&D activities close to their most sophisticated markets and close to the most advanced research facilities. R&D was increasingly seen as the key instrument for organizational learning. Internationalization had changed from being a technology transfer instrument to a means of enhancing the stock of knowledge, and to maintain competitiveness in key markets. To maximize the options for learning, MNEs are increasingly organizing their research laboratories into an integrated network of research facilities with individual laboratories charged with two general tasks: first, to establish effective links with host country science and technology activities, and second, to adapt company specific knowledge and technology to use in local markets (Bijman et al. 1997).

3. Geographical patterns of internationalization. The changing rationale of R&D has major implications for the location of different types of R&D in different countries. Under the technology transfer model the emphasis was on R&D structures that were centralized in the MNEs home country. Later on, multiple centers of innovation in the form of a "decentralized federation" became the model. But in many situations companies found that globally dispersed R&D activities resulted in quite complex and unmanageable organizational setups. This has led to a search for leaner organizational forms and a drive for increased control of dispersed R&D facilities, and to the formation of integrated R&D networks that aim to combine the advantages of being close to different markets with the need for coordination and control.

It is unclear whether in the future the emphasis will be on more centralized or on more decentralized systems. Albert (1999) summarized the main forces that promote centralization and decentralization respectively. Centralization is promoted by:

- the need to protect firm specific technology;

- the need to minimize organizational and transaction costs;
- the potential to benefit from economies of scale and achieving critical mass;
- the fact that R&D facilities are usually based in the home country which is often the most sophisticated market; hence there would be little benefit from replication.

Forces for geographical decentralization include:

- the need to be close to end-markets and users of innovations (demand side);
- the need to be close to existing sources of new technology and markets for highly skilled labor (supply side);
- regulatory requirements to maintain facilities in a variety of countries (e.g. for clinical testing);
- the need to keep abreast of competitor behavior.

Different types of companies pursue different internationalization strategies that result in a variety of different configurations of their R&D networks. A number of authors - e.g. (Gerybadze and Reger 1999, Archibugi and Iammarino 1999, Bijman, et al. 1997, UNCTAD 2005) have produced taxonomies and typologies of internationalization. Most of these have in common that they make a basic distinction between what a company does in its home base and in host countries. In this respect (Kuemmerle 1999) refers to home base exploiting types of internationalization that are broadly consistent with the technology transfer model and home base augmenting forms that correspond to a learning mode of internationalization.

4. The emergence of new organizational models such as R&D alliances. Internationalization strategies affect organizational models, in particular with regard to alliances and technology partnerships. In addition to deciding on where to locate their own R&D facilities, MNEs need to define and often redefine organizational boundaries. The arguments for bringing or keeping host country R&D facilities inside the MNE are usually based on the need to reduce transaction costs. But there are a number of advantages to co-developing new technology or to engage in an alliance. These include the increasing complexity of societal issues and problems, the blurring of boundaries between countries, between public and private sectors and between scientific disciplines. Dunning (1998) in this context refers to the emergence of alliance capitalism (a.k.a stakeholder capitalism) as the new organizational modality.

With regard to the respective roles of public and private sectors Archibugi and Iammarino (2000), echoing Rodrik’s (1999) plea for strengthening domestic institutions in order to benefit from globalization, argue that the increasing internationalization of private sector R&D and the global generation of innovations requires expansion, rather than reduction of the public policy portfolio. Public policies are needed to monitor R&D activities and to ensure adequate returns for public investments in R&D. In order to benefit from increased knowledge and technology generated by the private sector, and to remain credible partners in alliances, the public sector will need to advance it is own technological capabilities.

Pray and Umali-Deininger (1998) have explored the potential role of the private sector in agricultural research in developing countries and asked whether it will fill the gap created by reduced public research expenditures. They conclude that there are certain areas where national governments may be able to rely on the private sector to promote agricultural R&D (biotechnology and input industries are important examples), but that it is unlikely that the private sector will indeed fill the gap caused by the withdrawal of the public sector in many countries.

2.6.2 International public agricultural R&D

International agricultural research has played a major role in post World War II international agriculture. An important rationale for public investment in agricultural R&D has been its concern with the production of public goods, characterized by low levels of appropriability and excludability, and by high potential spillovers (Anderson 1998). In addition, strategic preoccupations with national food security and concerns over hunger and poverty have traditionally kept the agricultural research portfolio well filled, thanks also to large investments by international donors.

Since 1990, however, investments in public agricultural research as a percentage of agricultural GDP have stagnated. “Donor fatigue”, institutional failures of developing country public sectors, and the end of the cold war, which significantly decreased the strategic value of many developing countries to the West all contributed to stagnant budgets. This has affected national agricultural research in developing countries directly, as well as indirectly, through reduced support to international agricultural research. The main international actors include the Centers of the Consultative Group on International Agricultural Research (CGIAR), and national agricultural research organizations and universities from the developed countries, through their international research and training activities (Dalrymple 2000). The donor-owners of the CGIAR, including the World Bank and national donors have significant influence on the CGIAR research agenda. The Food and Agriculture Organization (FAO) of the United Nations plays an important role through its agricultural development, institution building, and information activities. NGOs, as yet, play a minor role in international agricultural R&D.

The CGIAR’s main early success that has contributed significantly to overcoming food shortages in Asia was formed by the new (semi-dwarf) rice and wheat varieties that allowed a significantly higher production in a shorter time – in those areas where irrigation and inputs such as fertilizer were available. Adoption of these varieties in Asia is almost universal and the CGIAR has expanded to include new commodities, regions and environments. The spectacular success of the green revolution in Asia could not be repeated in other regions and with other crops. But even though productivity in other crops did not increase as dramatically as with rice and wheat, the overall returns to investments in agricultural research have consistently been demonstrated to be high (Alston et al. 2000).

The main trends that affect the organization, funding and characteristics of international agricultural research are the following:

1. Agricultural research is affected by a changing policy environment in which the independence and special status of the agriculture and food sector is disappearing. Agriculture used to be seen as a public concern with a key role for government to ensure food

security. But if they work reasonably well, markets, rather than governments can be relied on to provide food security and agriculture is increasingly seen as a private good. As a result, the emphasis has shifted to “new” public goods or public goals, where market failures can be observed: food safety, environment and poverty. A much wider array of interest groups are now involved in agricultural research and development. Agricultural development is seen as part of the broader rural development agenda and research is increasingly seen as instrumental in the development agenda.

2. Since the 1990s food security and famine were no longer seen as the threat they once formed. Many major developing countries (India, China, Indonesia, Brazil) that used to have food shortages have become self-sufficient or have become important agricultural exporters. As the Malthusian threat has been proven incorrect time after time, the urgency to develop new technologies appears to have diminished for many donors. In order to feed a growing and generally more affluent world population and to eliminate hunger with a shrinking natural resource base, yields in developing countries will have to grow very significantly in the next 20 years (Swaminathan 2007). Yield increases will be even more urgent as a very long period of declining real food prices appears to have come to an end in 2006 with rapid increases of all commodity prices, including oil and food, driven by rapidly rising imports in developing countries (most importantly China) and the use of food grains to produce biofuels (Birur et al. 2007, FAO 2007, The Economist 2007b).

3. The funding, organization and governance of public agricultural research and innovation is strongly affected by the ideas from new public management (See chapter 4). The changing (and declining) role of the public sector has led to a decline in funding, in privatization of certain tasks and in new funding mechanisms with an emphasis on competitive research funding.

4. There is considerable conflict over key issues in the international agricultural research and development agenda, with different models and paradigms competing for attention and influence. This study will elaborate the emergence of four different paradigms based on the green revolution, sustainability, biotechnology and the growing role of international agri-food chains. These paradigms can be seen as techno-institutional regimes or selection environments for specific agricultural innovations.

2.7 Conclusions

A number of conclusions on the globalization and internationalization of agriculture and of agricultural R&D can be drawn:

First, globalization and internationalization are highly disruptive processes with major implications for developing countries. Internationalization processes will continue to shape agriculture, as they are driven by decreased barriers to trade and the information revolution. Internationalization is therefore a major driver of change in agriculture and in agricultural R&D and innovation.

Second, internationalization affects agricultural R&D and innovation in a variety of ways. Internationalization affects agricultural R&D and innovation in a direct manner through increased trade and FDI (Rodrik's goods and capital). Indirect effects are the result of changes in institutions (at international and national level), and the introduction of new ideas (mainly technological change).

Third, trade in agricultural commodities is increasing rapidly – both in volume and in types of commodities traded. This has two implications. One is that most Asian countries started to change their traditional policies aimed at self-sufficiency in key commodities (although export restrictions were reimposed when food prices soared in 2006 and 2007). Another is the emergence of new global agricultural value chains for high-value fresh agricultural products.

Fourth, FDI in agriculture in developing countries is small compared to FDI in manufacturing. Yet, the expansion of two types of international agribusiness MNEs is having a major impact on Asian agriculture. On the one hand, life science and seed companies have increased their presence significantly since the 1990s and are introducing new hybrids seeds, agro-chemicals and GM varieties at a rapidly increasing pace. On the other, food producing companies and retailers are introducing new products, agricultural production systems, and ICT-based logistics.

Fifth, whether developing countries benefit from internationalization depends to a large extent on national capabilities and domestic institutions. These include capabilities to formulate national policies in response to internationalization, access to and dissemination of information, research and innovation capacity, efficient markets and market integration, and effective regulatory institutions.

Sixth, R&D and innovation are rapidly becoming global activities. Agri-food multinational companies are building integrated networks of R&D facilities, which balance the need for control and economies of scale with the need to adapt to local markets (resulting in a particular mix of centralization and decentralization). Public agricultural R&D expanded rapidly in the 1980s, supported by international donors, as food security was a major concern. It stagnated since the late 1980s as a result of structural adjustment and privatization policies, and emerging food surpluses. Since 2000 public agricultural research is gradually making a comeback as new public concerns are emerging: environment, food safety, pandemics, and climate change.

3. R&D, technological change and agricultural innovation

3.1 Introduction

In his chapter on "Innovation Processes" for the Oxford Handbook of Innovation, Keith Pavitt (2005: 87) writes that: "[s]ince there is more than one process of innovation, there is no easy way to organize this chapter." And while Pavitt's review is limited to innovation processes within the firm, the present chapter also addresses innovation processes between actors, including the role of research and extension organization, and farmers. A focus on dissemination and adoption of innovations between organizations is crucial to the understanding of agricultural innovation.

This overview of agricultural innovation is structured as follows. The analysis starts with the question what innovation is, and presents a number of definitions, debates and controversies on types of innovation (section 3.2). This is followed by a discussion of innovation processes, an analysis not limited to processes with in a firm, but focused on how innovation processes operate between actors and institutions (section 3.3). This results in the presentation of an interactive model of innovation. The next section (3.4) elaborates on this by discussing processes of learning and knowledge creation that are at the heart of the innovation process. Section 3.5 presents in more detail some issues related to agricultural research and innovation, and 3.6 presents conclusions.

3.2 What is innovation?

3.2.1 Disciplinary traditions in the study of innovation

Innovation is major field of research in the management literature, in economics, and in the social sciences (sociology, science and technology studies, and geography). Views of the nature and the process of innovation often differ as much within, as between the disciplinary traditions.

The ***management literature*** often builds on the seminal work of Schumpeter who elaborated a theory of entrepreneurship in innovation processes. The entrepreneurship model of innovation is the oldest and stresses the personality characteristics required to make a good entrepreneur and innovator. Schumpeter's emphasis on the relationship between entrepreneurship and innovation has received a strong following in the management literature. Drucker (1998: 157), for example, observes that: "…the very foundation of entrepreneurship – as a practice and as a discipline – is the practice of systematic innovation".

The entrepreneur, in Schumpeter's view, is not an inventor, but rather someone of practical action who combines different elements to introduce a new product, process, or enter a new market. Views of the role of the entrepreneur in innovation have evolved in Schumpeter's thinking. Initially, his emphasis was on the characteristics of the individual entrepreneur who established an enterprise. Later in the 20th century, as corporations grew and formalized the R&D function, the emphasis shifted towards a collective innovation perspective. This reflected the professionalization of R&D and emphasized the role of teams, usually based in an R&D department. More recently, attention has returned again to the role of the individual entrepreneur, in particular as a result of the success of high-tech start-up firms that developed into major corporations. As a result, innovation is seen as the most important source of competitive advantage for companies. A key difference with earlier views is the importance attached to the entire organization being innovation-driven.

Much of the neoclassical ***economics*** literature has ignored technical change, or treated it as an exogenous phenomenon. This tradition concentrated on the analysis of technical change as the economic effect of innovation and has neglected innovation processes as such. Technical change, in neoclassical economics, is seen as an outward shift of the production function (Roseboom 2003). This approach was developed by Hayami and Ruttan (1985) in the presentation of a metaproduction function as the basis for their theory of induced innovation in agriculture. The theory of induced technical change has different strands, but a common element is that technical change is caused, or induced by factors in the broader economy: changes in demand, or changes in the relative prices of production factors. When, for example, land becomes increasingly scarce, there will be a premium on land-saving technologies. In the long run the metaproduction function includes all alternative feasible factor-factor and factor-product combinations. The induced innovation theory will be discussed in more detail in section 3.3 on innovation processes.

Baumol (2002) has attempted to explain the "growth miracle of capitalism" through an analysis of the "free-market innovation machine" by placing innovation at the center of microeconomic theory. The core of his argument is that large companies no longer just compete on producing the cheapest products, but on the production of high quality, innovative products: "… *innovation has replaced price* as the name of the game in a number of important industries" (Baumol 2002, italics in original). Large oligopolistic companies who are the main innovators have managed to achieve competitive advantage through the routinization of innovation processes – which allows them to turn out innovative products on a regular basis. While it is true that large companies are the main R&D spenders and the most important patent holders, this analysis seems to overlook the importance of small high-tech startup companies who are of crucial importance in generating new technologies and products (Clarysse et al. 2000).

Evolutionary economic theory, rejects the neo-classical approach and follows the "Schumpeterian" tradition in its interpretation of the process of technical change, highlighting the importance of both the role of individual entrepreneurs and of organizational routines. Based on Nelson and Winter (1982), and elaborated by Dosi et al. (1988), it treats technical change as an endogenous factor and focuses on the behavior of the firm in order to provide a realistic description of the technical change process. In contrast to the theory of induced innovation where technical change is caused essentially by changes in demand or in relative factor prices, evolutionary theory emphasizes science and technology related factors as the basis of technical change. Like evolutionary economics the path dependence model has a strong historical dimension: it states that a particular "dominant design", once established, has major implications for the choice of techniques in the future (Ruttan 1996, 1997). Producers and consumers become "locked-in" a specific technological development path.

Authors in both the evolutionary and the path dependent tradition see their work explicitly as a more comprehensive alternative to the neo-classical, induced innovation theory. In a reaction to Ruttan (1996) Dosi (1997) argues that the evolutionary theory can easily accommodate inducement effects and path dependent patterns of technical change. The main mechanism at work is that changes in factor scarcities would impact on the search behavior of the firm and on the resources allocated to searching different types of technologies or solutions.

The social sciences, especially ***sociology***, geography and anthropology have concentrated on adoption and diffusion of innovation, and on issues of resistance to change. In large organizations such as private sector corporations with their own R&D departments, the generation and application of new technology takes place under one corporate roof. This is not the case in most small businesses, particularly those in relatively "low-tech" sectors such as agriculture. Here, technology is often generated by specialized research and technology Institutes, outside the farm that uses the technology. In such a situation of technology produced by a few institutes for use by a large number of geographically dispersed agricultural producers, the adoption and diffusion of new technology becomes a major issue. Social science research on adoption and diffusion of innovations has a strong empirical orientation and typical questions asked refer to the variables related to innovativeness, the measurement of the rate of adoption and factors explaining it, and the role of communication in the innovation process (Ruttan 1996).

A distinct pro-innovation bias can be observed in much of this literature, which finds itself squarely in the "modernization" tradition in social science research. Farmers who do not adopt new technology are seen as "resistant to change" (Wharton 1971) with the farmer rather than the technology seen as the problem. While adoption and diffusion studies were very prominent in the 1960s and 1970s, their importance in the sociological tradition started to decline in the 1980s. In developed countries the main reason for this decline was related to mounting food surpluses, which seemed to reduce the urgency of further innovation diffusion work. In developing countries the declining interest in innovation studies has been attributed to the critical tradition in the social sciences, which came to see new technology as the problem, rather than the solution of development problems. This debate on the nature of new technology has been prominent in agriculture from the days of the green revolution (Griffin 1979) to the current controversy around biotechnology.

In an overview of adoption-diffusion research, Ruttan (1996) observes that the decline of diffusion studies in rural sociology coincided with an expansion of research by economists and technologists. Economists working in the neo-classical tradition stressed that substitution, rather than diffusion was the main issue in technical change. They also argued that non-adoption of innovation is not so much caused by communication problems, but rather by the fact that new technology is often not (yet) competitive and involves uncertainty and risk. The debate of whether non-adoption of new technology is caused by intrinsic characteristics of the technology (lack of profitability) or by lack of communication and information channels has been a persistent point of discussion in agricultural innovation. It is particularly strong in the agricultural research vs. extension debate, where researchers tend to blame non-adoption on inadequate extension, information and training, while extension specialists point the finger at the irrelevance, inappropriateness or lack of profitability of new technology (Anderson and Feder 2003).

3.2.2 Innovation issues and debates

Some important debates on innovation relate to whether it originates mainly from new technologies or from new demands in the market. Other issues concern the distinction between innovation and technical change, and the relationship between innovation and diffusion.

Technology push and market pull. A major debate has focused on whether innovation is largely the result of scientific breakthroughs or the result from changing markets and patterns of demand. Dosi (1982) argued that market induced changes tend to lead to "incremental" innovations, but changes in demand and factor endowments cannot explain the emergence of radically new technologies. The latter bring about new technological paradigms that guide the innovation and technology development processes for a significant period of time. A consensus has emerged that strong versions of both technology push and market pull models are inadequate (Dosi 1982) and that there are many possible sources of innovation (Biggs 1990). This discussion has important implications for innovation processes and is elaborated in more detail in the following section.

Innovation and technical change. The term innovation is often loosely used as synonymous with technical (or technological) change. Beije (1998: 31) argues that it is important to distinguish the two: "[t]he concepts innovation and technical change have a different meaning, although not all studies in the economics and management of innovation make this distinction". In Beije's view each innovation brings about a technical change, but not every technical change is an innovation. Therefore, the economic impact of the use of new technology is referred to as technical change, while the creation and implementation of new technology is called innovation. "Technical change is therefore the more encompassing concept, it includes: innovation, imitation and diffusion" (Beije 1998: 31).

Others, including Dosi (1988: 222) use a broader definition of the concept of innovation: "In an essential sense, innovation concerns the search for, and the discovery, experimentation, development imitation and adoption of new products, new production processes, and new organisational set-ups". In a broad concept of innovation the adoption of new-to-the-firm and new-to-the country technologies is clearly seen as innovation (World Bank 2008). Also, Dosi's definition of innovation broadens the concept to include non-technological types of innovation such as new institutional and organizational arrangements.

Innovation and diffusion. Diffusion of innovations and their adoption are key concerns in agriculture. Social scientists such as Rogers (1995) have studied diffusion processes and categorized technology users as "early innovators" and "late adopters". Adoption processes often follow an S-curve: slow growth of adoption in the early stages, followed by rapid growth once the innovation becomes more widely known, leveling off again when markets become saturated. Geographers such as Hägerstrand (1967) have studied the diffusion of innovations in relation to spatial characteristics. Diffusion is important in agricultural innovation as the potential users of new technology are many and are spread over a wide geographical area. This focuses attention on the diffusion of innovations and the mechanisms that hinder and enhance the adoption process.

Diffusion patterns differ between types of innovation: incremental innovations that build on existing knowledge are diffused and adopted more readily than technologies or practices that are fundamentally new. This applies both between and within organizations. The R&D department of a large corporation, for example, would normally be expected to have ready clients for their innovations in the company's business units – although stories of corporate resistance to change abound as well (The Economist 1999, Chesbrough 2003).

Governments and innovation. As innovation is increasingly seen as the most important source of economic growth (Baumol 2002), the promotion of innovation has become an important public concern. Innovations do not get readily adopted, resulting in a situation of market failure that justifies the development of government policies. Others (including Baumol) see a problem of government failure and the best policy for governments would be to get out of the way.

Edler and Georghiu (2007) on the other hand emphasize the important role that governments can play in demanding new and innovative products and services. They present a taxonomy of public policies to promote innovation, making a clear distinction between supply side and demand side measures. Demand side policies that government may use include the support of private demand, regulation and especially public procurement. Supply-side policies come in two main types: finance and services. Financial policies include fiscal measures, support for public research, grants for industry R&D, and support for training and mobility. Services include brokerage and networking activities.

3.2.3 Types of (agricultural) innovation

The literature distinguishes between major, systemic innovations and small incremental innovations. Other ways to distinguish innovation technical vs. institutional innovation, and closed vs. open models of innovation.

Systemic and incremental innovations. The impact of some innovations is much more profound than that of others. The evolutionary economics school (Dosi 1982) introduced the idea of technological paradigms and trajectories to distinguish radical innovations from incremental ones. In an analogy to Kuhn's concept of scientific paradigms, technological paradigms are frameworks that guide periods of "normal" technology development. Once a technological paradigm is established, it guides the way and defines the technological opportunities for further innovations. This is the idea of technological trajectories, similar to the notion of path-dependent innovation. Freeman and Perez (1988) use the expression "techno-economic paradigm" to describe fundamental and pervasive technologies that dominate the behavior of firms. Dosi (1982) rejects the "strong" versions of both the demand-pull and technology-push models and proposes a more interactive approach, in which market-induced innovations refer to "normal", incremental technology development. At the same time market induced changes do not explain the emergence of radically new innovations, which are the product of relatively autonomous developments in science and technology.

Technical and institutional innovation. The concept of innovation has been used in a narrow sense, referring to technical innovation, and in a much wider sense. An important tradition goes back to Schumpeter who was the first economist to give a key role to the entrepreneur in the innovation process. He distinguished innovation from invention and used the term in very broad sense, defining the task of the entrepreneur as: "… to reform or revolutionize the pattern of production by exploiting an invention or, more generally, an untried technological possibility for producing a new source of supply of materials or a new outlet for products, by reorganizing an industry and so on" (Schumpeter 1976: 132). Innovations are any "new combinations" of existing or new technologies or practices. Innovations include new products, new processes, new distribution methods, new ways of operating in markets, and new management practices and organizational structures. An important insight – discussed at length in chapter 4 – is that that technical innovation needs to go hand-in-hand with institutional and organizational innovation (Radosevic 1998).

Closed and open innovation. Increasing market competition, globalization, and the ICT revolution are the main drivers behind the trend towards more open innovation models (Chesbrough 2003, The Economist 2007a). A focus on core competencies and on outsourcing of parts of the production and innovation process leads to decomposed, but globally integrated value chains, and to networked types of R&D and innovation. The key concern is accessing external expertise, which becomes increasingly necessary as no company or research institute can cover the entire knowledge chain by itself. There are many reasons to access external knowledge. One is that technologies become increasingly complex and interdisciplinary. As a result they also become more costly, hence the search for cost and risk sharing arrangements. Increased competition includes the need to bring products to market faster, and accessing external knowledge is usually faster than building up a knowledge base internally. The basic ideas behind open innovation were already well captured by Foster (2000: 1):

> "The key survival skill will not be conducting R&D so much as creating innovation. Increasingly R&D will be the "make" option in a "make or buy" world. More technology than ever before will be available for license or exchange, and internal R&D departments will have to compete effectively with these external sources."

Table 3.1 Open vs. closed innovation principles

Old ´closed´ innovation	New ´open´ innovation
• We have the smartest people	• Many smart people outside
• We discover, develop and market ourselves	• Internal R&D cannot cover all needs
• To be first to market means winning	• External R&D also creates value.
• Create most and best ideas means winning	• To achieve market growth means winning (also if it has to be shared)
• Control IP to control entrance of competitors	• Profit is in combining internal and external processes in a good business model
	• Sharing IP is becoming the rule

Source: Chesbrough 2003

The idea of open innovation systems is based on the notion that there are multiple sources of innovation and that innovation often originates in unexpected places. Companies, lead users, universities, research departments and public research organizations, consumers, NGO's can all play a legitimate role in the innovation process. The new innovation landscape is no longer characterized by secure positions of established organizations. Rather, a situation emerges, where flexible contracts or exchange-based arrangements are the basis for interaction between organizations. Compared to the closed innovation paradigm there is more competition in de open innovation system. At the same time a new balance needs to be found between competition and cooperation in networked organizations. Table 3.1 presents a summary of the differences between open and closed innovation.

3.3 Innovation processes: produced or induced?

This section presents a simple classification of innovation processes. It distinguishes two main approaches: innovation produced by actors vs. innovation induced by external factors. The actor-based models of innovation operate at the micro level of analysis and address questions of how the innovation process takes place (who adopts?). Factor-based approaches tend to analyze innovation processes at the macro level and focus on the variables that explain why innovative activity occurs. Within the two overall approaches there are different views about which factors or actors are, in fact, responsible for innovation. Factor-based approaches fall in two main groups: those that see innovation as induced by science and technology, and those that emphasize the role of product and factor markets. Actor-based approaches discuss the different roles of producers, users and others.

3.3.1 Induced innovation approaches

Science and technology based models assume that innovation is induced by developments and changes in science. The basic science-push model takes a linear perspective:

> "Considering the complexity of the institutions and processes which create and diffuse innovations it is natural to seek useful simplifications to guide policy. One such simplification is provided by the linear model of innovation. This proposes a series of discrete stages of innovation, arranged in a strict sequence, proceeding from the acquisition of fundamental knowledge through to the introduction of artefacts in the market. The origin of the linear model can be traced to Schumpeter's sequence of invention, innovation and diffusion in strict temporal sense, with, along the way, the insertion of value judgments about the relative contributions of science and technology to innovation" (Metcalfe 1995: 462).

The science and technology push model stresses the importance of new knowledge as the source of innovation. Or, in Dosi's (1988: 222) words: "In fact, technological innovation has been able to draw, and increasingly so in this century, from new opportunities stemming from scientific advances (from thermodynamics to biology, electricity, quantum physics, etc.)". The increasing reliance of major technological opportunities on advances in scientific knowledge is, according to Dosi, a major property of contemporary innovation. But others believe that this overstates the role of science and technology in the innovation process. As

Metcalfe (1995: 462) realizes: "Scholars now recognize a much more complex situation with many feedbacks and a blurring of boundaries between the hypothetical stages."

The theory of induced innovation**,** as it has been developed in economics, highlights the role that product and factor demand and, in general, market conditions play. This model has become known as the market-pull model. The model was originally developed by Schmookler in a study of patents that claimed that demand determines the direction and rate of technological change (Beije 1998). In Schmookler's view scientific knowledge and capabilities are applicable to a wide range of industrial products and processes. A common pool of knowledge and technology is available at a given time for application in industry. Growth and change in market demand determines to which specific products and processes the innovative effort is applied[6]. However: "Schmookler's proposition that demand almost alone determines the rate and direction of technical change has not survived empirical scrutiny" (Stoneman, 1995: 212). Similar to Dosi (1982), Cohen (1995: 212) argues that: "…relatively exogenous major innovation induces growth in demand, which in turn creates the incentive for subsequent incremental innovation."

Demand-pull theories in their basic form according to Dosi (1982) constitute a rather crude conception of technical change as an essentially reactive mechanism based on a black box of readily available technological possibilities. The crude version of a pure demand-pull theory would include the following elements:

- a set of goods satisfies different 'needs',
- patterns of demand demonstrate consumer preference,
- with growing income (releasing budget constraints) consumers demand more goods that embody preferred characteristics,
- this process reveals to producers the needs of consumers which they in turn will cater for through new products.

Dosi (1982) lists three weaknesses of strong versions of demand pull theories. The first is the concept of passive and mechanical reactiveness of technological change to market conditions. The second is the inability to define why and when certain technological developments take place and others don't. And the third is the neglect of changes over time of inventive capability which have no direct relations to market conditions. The demand pull model, according to Dosi, fails to provide evidence that "needs expressed through market signaling" are the prime movers of innovative activity.

The traditional neoclassical approach to technology was to treat it as a fully exogenous variable (Lipsey 2002). When the inadequacy of this approach became apparent, alternative approaches such as the evolutionary economics sought to endogenize technology. At the same time, within the neoclassical tradition attempts have been made to anchor technology more solidly into the economic analysis. This includes Baumol (2002) discussed earlier.

[6] This has important implications for technology policy. If innovations are derived from a common pool of knowledge there is limited scope for specific technology policy. If, on the other hand, specific areas of technological progress can be identified, these become amenable to policy intervention.

Another prominent example in the neoclassical tradition that seeks to address the role of technology is presented in the induced innovation literature. Hayami and Ruttan 1985: 84-85) in their influential study argue that:

> "The process by which technical change is generated has traditionally been treated as exogenous to the economic system – as a product of autonomous advances in scientific and technical knowledge. The theory of induced innovation represents an effort to interpret the process of technical change as endogenous to the economic system. In this view technical change represents a dynamic response to changes in resource endowments and to growth in demand." …"The theories of induced innovation have been developed mainly within the framework of the theory of the firm. There have been two traditions in the attempt to incorporate into economic theory the innovative behavior of profit-maximizing firms. One is the Hicks tradition that focused on the factor-saving bias induced by changes in relative factor prices resulting from changes in relative resource scarcities. Another is the Schmookler-Griliches tradition that focused on the influence of the growth of product demand on the rate of technical change."

The induced innovation models are squarely rooted in the neo-classical microeconomic tradition. This is their main strength as indicated by Ruttan (1997), when pointing to the empirical evidence that has been collected in support of the induced innovation hypothesis. But as several authors (Lipsey 2002, Tabor 1997) have noted, it is also their weak spot. Tabor discusses four problems with regard to the neoclassical microeconomic approach. First, there is the general question of how well the neoclassical optimizing framework fits the environment to which it is applied. Specifically for developing countries the question must be asked if markets are working sufficiently well to provide efficient guidance to decision making about innovation and technical change. A second question relates to the role of institutions and organizations in innovation as discussed above. Some organizations are quite successful in generating innovations, irrespective of economic circumstances (Grindle 1997). Third, the induced innovation model ignores the role of governments and politics. There is considerable evidence, particularly from Asia, both from the agricultural and industrial sectors, that technical change and innovation processes have been strategically directed by governments. Fourth, the induced innovation model treats innovation as a rational micro-economic process and ignores more macro-economic aspects. "Agricultural innovation becomes a reactive, microeconomically rational process, rather than a component of a nationally-guided strategic process" (Tabor 1997: 139).

To address some of the criticisms of the induced innovation model Hayami and Ruttan (1985) have added an indirect route to the basic induced innovation model. The ***indirectly induced innovation*** model**,** as it may be referred to, adds an actor perspective to the induced innovation model in order to address certain inadequacies. As such it can be seen as a transition to actor-based models. The reason to add an indirect route to the basic induced innovation model is that small farmers cannot express demand for innovations effectively and that there is a role for researchers and research managers to translate producer problems and farmer demands into researchable activities that produce new technology. Here it is useful to quote Hayami and Ruttan again at some length, as their arguments are particularly relevant to public sector research and innovation:

> "A major extension of the traditional argument is that we base the innovation inducement mechanism not only on the response to changes in the market prices of profit-maximizing firms but also on the response by research scientists and administrators in public institutions to resource endowments and economic change. We hypothesize that technical change is guided along an efficient path by price signals in the market, provided that the prices efficiently reflect changes in the demand and supply of products and factors and that there exists effective interaction among farmers, public research institutions, and private agricultural supply firms. Farmers are induced, by shifts in relative prices, to search for technical alternatives that save the increasingly scarce factors of production. They press the public research institutions to develop the new technology and also demand that agricultural supply firms supply modern technical inputs that substitute for the more scarce factors. Perceptive scientists and science administrators respond by making available new technical possibilities and new inputs that enable farmers profitably to substitute increasingly abundant factors for increasingly scarce factors, thereby guiding the demand of farmers for unit cost reduction in a socially optimal direction." (Hayami and Ruttan 1985: 88) [7].

In the indirectly induced innovation model, the response of the research scientists and administrators represents the critical link in the inducement mechanism. They need not be consciously responding to market prices, or directly to farmer demands, but it is critical that incentives and rewards exist for researchers and managers to contribute to the solution of major problems in society. Effective farmer organizations and a mission or client-oriented research system constitute other conditions necessary for the induced innovation model to function.

In many cases, however, public sector institutions fail to respond effectively to changes in prices or to needs in society, as there seem to be powerful incentives for public sector institutions to choose maintaining the status quo over more dynamic approaches. In fact, this has become one of the main criticisms of public agricultural research organizations in developing countries (see Chapter 10).

3.3.2 Actor based approaches

Actor-based approaches to innovation may be contrasted in two different ways. First, a distinction can be made between producer-generated innovation and user-led innovation. Second, actors may orient their innovative strategy primarily towards developing or acquiring new technology as a source of innovation, or towards new opportunities in markets.

Von Hippel (1988) refers to the key actors in the innovation process as the ***functional sources of innovation***. Conventional wisdom has it that innovations are produced by

[7] Hayami and Ruttan have further extended their induced innovation model beyond technical change to include a model of induced institutional change following a similar line of reasoning. But the argument that institutional change is induced is introduced in a similar way as technical change has not been well accepted.

manufacturers and adopted by users. Von Hippel challenges this view and demonstrates that in many cases other actors such as users and suppliers play a key role in the innovation process. The functional sources of innovation depend on a number of conditions, especially on the expected temporary benefits (rents) to be obtained from innovation by different actors. Von Hippel stresses the importance of ***user-led innovation*** and emphasizes the role of "lead-users" in the innovation process. He presents a number of cases where the conventional view of the innovation process is turned upside down.

Often it is the user who feels the need for the improvement of a product, process or service. The user experiments, develops a prototype and demonstrates its usefulness, while the role of the manufacturer may be limited to production and diffusion. The user, requiring solutions to problems, is in the frontline of the innovation process. Von Hippel's work represents a significant contribution to the understanding of the innovation process, and as a result, it is now well accepted that innovation is an interactive process, involving a variety of different actors, none of whom can assumed to be *a priori* dominant in the process. The open innovation school (Chesbrough 2003) has been directly influenced by Von Hippel's findings. And the concept of user-led innovation has been carried to its logical consequence by Gershenfeld (2005) when he introduces the concept of personal fabrication or personal manufacturing in an analogy to personal computing.

Users who lead innovation may be different individuals or organizations than the technology producers (manufacturers, farmers, service providers), or they may find themselves within the same organization as the technology developers (e.g. R&D units and business units of a company). In the latter situation the distinction between user and producer-led innovation may sometimes be difficult to make as illustrated in the following two examples.

First, producer-generated innovation is important in large corporations with their own R&D departments. For strategic or for cost reasons, the company has decided to internalize the R&D function as it cannot, or does not wish to rely on external technology markets. This is particularly the case when technology is a key component of the firm's strategy and is seen as a source of competitive advantage, when assets are highly specific, and when the innovations generated are largely intended for use by the company's own business units. This is the traditional corporate R&D model that is challenged by open innovation. But not only large corporations develop technology in-house. Smaller businesses may be technology-driven and agricultural producers have always been known to experiment with new technologies and production practices. Without the support of more formalized research efforts, however, the innovative effort may remain limited to adaptation of existing technologies.

A second example where the producer of innovation is also the user involves the innovative behavior of farmers who experiment with new combinations in the way Schumpeter described the innovative behavior of the entrepreneur[8]. Many examples of user-generated innovation can be found in the "indigenous knowledge literature" (Sillitoe 2006). The indigenous knowledge school emphasizes that farmers are active search agents, looking for

[8] Where farmer experimental behavior involves the use of external inputs, as it often will, producer-generated innovation may change to user-led innovation as discussed by Von Hippel.

solutions. But the indigenous knowledge literature is usually critical of technology introduced from outside the farming system, which is often seen as a problem rather than a solution. The indigenous knowledge school emphasizes the value of traditional knowledge and practice, which needs to be combined judiciously with modern technology if farmers are to benefit (Warren 1991).

From an actor perspective the distinction between technology-oriented strategies and market-oriented strategies is also important. ***Technology-oriented strategies*** seek explicitly to develop, commercialize and exploit new generic technologies. They have in common with the technology-push model the key role attributed to science and technology, but differ as they emphasize the importance of the technology user in searching actively for innovations (Sundbo 1995). In technology-oriented strategies, the entire organization is focused on innovation through technology development. In large, diversified corporations, on the other hand, with in-house R&D departments, technology is just one of many sources of competitive advantage. Technology-oriented strategies have led to the typical “high-tech” (startup) companies in areas such as information and biotechnology. Supported by improved intellectual property protection and technology policy measures that financed private technology development with public money, technology-oriented strategies have sped up the pace of innovation in all advanced economies (The Economist 1999). Technology-oriented strategies are becoming increasingly important in agricultural innovation, as new ICT and biotechnology opportunities are now available that require active searching and scanning by innovation actors (e.g. agricultural research organizations and innovative farmers).

A ***market-oriented strategy*** views the innovation function from a pure marketing perspective. Innovation is to see new possibilities in the marketplace and to exploit these by marketing new products, or to market existing products in a new way (Sundbo 1995). Here innovation is not seen as broadly induced by changing market and factor prices, but as a conscious activity, and a core strategy of the organization.

This strategy has become prominent since the 1980s, when authors such as Mintzberg (1994) and Porter (1996) identified innovation as the key factor in strategy theory. Porter (1996) advises companies wanting to innovate to identify the most sophisticated and demanding buyers, or those with the most difficult needs. They should try to exceed product specifications and regulatory norms and standards. In other words: in order to achieve innovation they should confront the competition, not shelter from it. The strategy literature focuses on the role of top management in the process of innovation that leads to competitive advantage. The market-oriented innovation perspective has become particularly prominent in low-tech and service-type of industries, including agriculture and food– witness, for example the constant stream of novel food products in supermarkets. In this mode, the nature of the innovation process is not limited to technological innovation, but includes a variety of process and organizational innovations.

Market-oriented innovation models are also strongly pull-oriented. Market conditions establish when a particular product or service becomes outdated, and they determine the scope for innovation. The involvement of customers or clients in the innovation process is a key element of the market search model. Porter (1996) emphasizes that the basis for strategy is not "operational effectiveness", which can be achieved through emulating best practice approaches, but to do things uniquely different from competitors. A unique way of serving customers, serving a new group of customers, or devising a new way of organizing the production process to produce value form the basis for developing a unique knowledge position and for providing an innovative product or service.

3.3.3 Towards an interactive innovation model

In a comparison of induced innovation, evolutionary economics and path dependence Ruttan (1996) concludes that it appears that all three have reached a dead end. The induced innovation tradition has been productive of empirical research, but the model is driven by exogenous changes in the firm's external economic environment, while the fundamental process of learning, research and development remains inside a black box. Evolutionary theories, on the other hand aim to shed light on the inner workings of the black box, by building on the behavioral theory of the firm. The evolutionary approach, while conceptually rich, has, however, not become a productive source of empirical research. Path dependence approaches, while providing useful insights take a more narrow perspective and do not explain the forces that drive technical change.

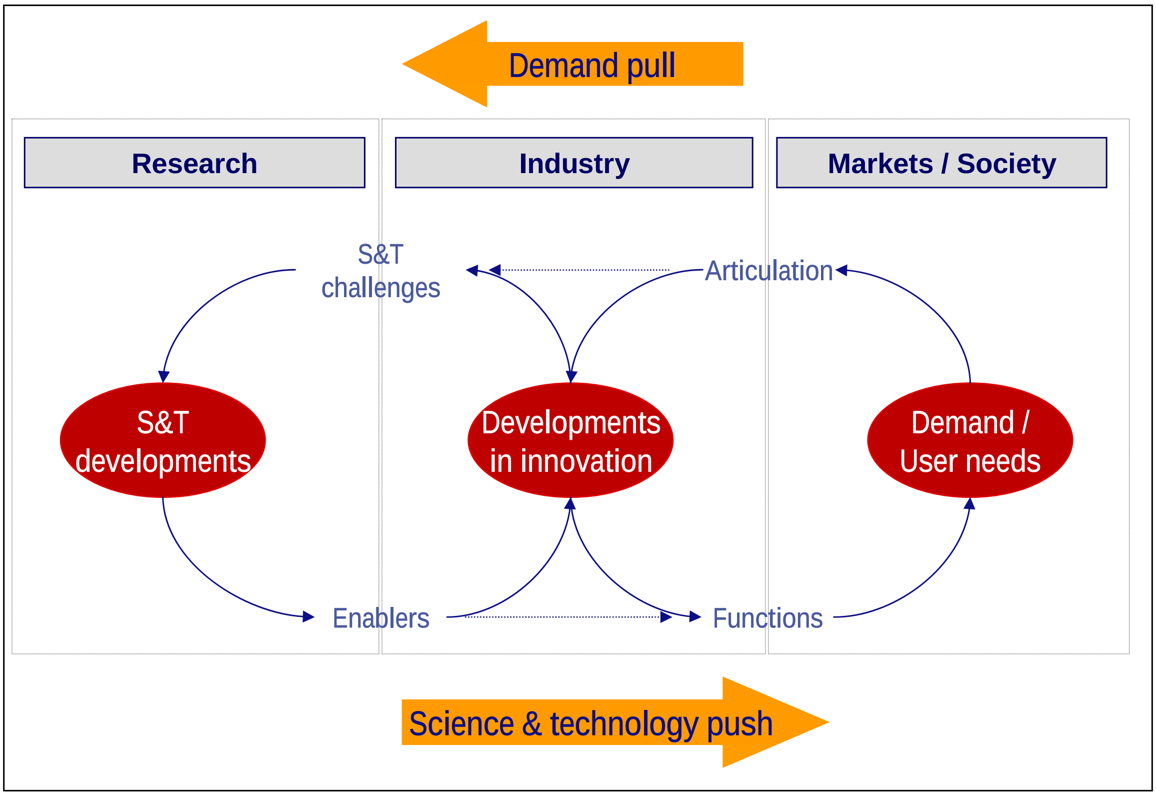
From the perspective of a technology user, whether an individual or an organization, the innovation process involves a number of internal and external actors related to the production, transfer and diffusion of new products or processes. In the case of agricultural innovation Biggs (1990) has contrasted a "central source of innovation model" with a "multiple source of innovation model". In the central source model institutions have clearly defined and unambiguous roles; there are clearly identifiable stages in research and extension; a hierarchical structure, reinforced by dissemination networks, assures transfer of materials and information; innovation flows from top to bottom; and the process is seen as primarily technical and a-political. The multiple source model emphasizes experimentation and innovation by technology users; it recognizes the role played in innovation by a variety of organizations (such as NGOs and private sector companies and international research organizations); it places innovations in their historical context; and recognizes the importance of the political, economic and institutional context. Also, the multiple source model emphasizes that different actors in the R&D process have different motives and interests, but that they interact in competing or cooperating ways to develop and adapt new technologies and innovations.

Open innovation models also clearly emphasize the need for interaction in innovation processes: to access external knowledge and technology, to develop new technology with other partners, to find out about demand, to agree on standards, etc. There are increasing demands from a wide variety of societal stakeholders for more transparency ("see-through-science", Wilsdon and Willis, 2004) in research and innovation and to involve stakeholders and the general public more effectively in research and innovation processes.

Leydesdorff (2000, 2005) introduces the idea of interactive innovation using the metaphor of a "triple helix" with universities, industry, and governments as the constituting elements. The involvement of three different types of actors introduces an element of complexity and instability in the relationships between the different actors, leading to complex patterns of lock-in, lock-out, substitution and return to equilibrium.

Figure 3.1 illustrates innovation as an interactive process, which involves a constant flow of information, ideas, materials and people between markets, companies and research institutions. It allows for both science-push and demand-pull in the innovation process. Innovations are developed when market demands or societal needs are articulated and become explicit. Companies may be able to respond directly by developing new products and services in-house, or they may need research inputs from universities, research institutes or their own R&D labs. Research actors may respond to developments and opportunities that arise from scientific advances, through new "enabling" technologies, or they may respond to demands from producers or users of new technologies. An important feature of the interactive innovation model is that it requires constant learning, both within and between organizations.

Figure 3.1 Innovation as an interactive process



Source: Based on Butter and Hoogendoorn 2005

3.4 Innovation and learning

Learning and knowledge creation are at the core of the innovative process. Learning takes place at individual, group, organization and inter-organizational levels. Questions relating to obtaining and maintaining the potential to innovate have been addressed in evolutionary economics, in the organizational learning literature and in the literature on knowledge management.

In economics there are essentially three theories of the firm with very different perspectives on organizational learning (Beije 1998). First, in the neoclassical economic literature the firm is seen as a production function, and learning is not recognized as an issue. Second, in the New Institutional Economics the firm is seen as a governance structure designed to minimize transaction costs. It focuses more on the allocation of existing resources than on the creation of new resources, and learning, therefore, plays a minor role. Third, evolutionary economics has aimed to provide a counterweight to the neoclassical and the transaction cost perspectives.

The evolutionary approaches to economics take a historical perspective and see the firm as a "bundle of routines" – and these routines need to be learned. Innovation is path dependent and follows technological trajectories, where innovations build to a large extent on earlier work. Search activities, constrained by the context of technological trajectories, play an important role in evolutionary economics. These search activities take two different, and complementary shapes, that of formal R&D work, and that of more informal, experiential "learning-by-doing" and "learning-by-using" activities (Rosenberg 1982). The fact that organizations can learn how to use, improve or produce things "by the very process of doing them through their 'informal' activities of solving production problems, meeting specific customers' requirements, overcoming various sorts of bottlenecks" is a key element of innovation for Dosi (1988: 223). The knowledge required to solve these different problems also comes in different sorts: some of it is well articulated and written down in manuals, procedures and textbooks, while other knowledge is largely tacit, implicit, learned through practice, and communicated through practical example.

Nooteboom (2000) argues that, while there has been an enormous growth in the economics literature dealing with bounded rationality, asymmetric information and incomplete contracts, it has not addressed learning issues in any significant way. Learning in economics has a very limited perspective: it deals with issues such as increasing technical efficiency and the acquisition of knowledge through spillover effects. The literature on management and organization, on the other hand, has developed theories of learning that are much more comprehensive: they explore the implications of cognitive distance between partners, the notion of absorptive capacity and, most importantly, they incorporate ideas of exploration (in addition to exploitation) beyond a set of known alternatives, thereby entering the area of radical uncertainty. Under radical uncertainty one cannot proceed by rationally selecting from a set of alternatives – rather action through exploration will reveal the alternatives.

The idea of innovation as an evolutionary process that involves learning under conditions of uncertainty (one cannot know *a priori* what will or will not work) has been developed by Douthwaite et al. (2002) and Douthwaite (2006). The central idea is that innovation involves "learning selection", a process analogous to Darwin's natural selection processes and which involves novelty generation and selection of beneficial novelties (Nelson 1987). The agricultural innovation processes described by Douthwaite et al. (2002) involve a large number of participants and require learning within and between actors. The learning selection process involves a number of steps:

- ***Concrete experience*** is the beginning of the learning cycle – e.g. a pest problem in a farmer's field.
- ***Reflective observation*** is the process of reflecting on this experience from different points of view and/or by different actors.
- ***Abstract conceptualization*** involves the development of possible explanations or theories that may explain the problem and point towards a solution.
- ***Active experimentation*** with one or more possible solutions results in innovation and may lead to new cycles of learning and selection.

The organizational learning literature builds on and expands these ideas on learning and knowledge creation. Nonaka (1994), for example, elaborates a "dynamic theory of organizational knowledge creation". The basis for Nonaka's model is the distinction between tacit and explicit knowledge. Explicit knowledge is that knowledge, which can be expressed and transmitted in formal systematic language, often presented in documents. Tacit knowledge is that knowledge, which often cannot be expressed easily; it is rooted in action, commitment, and involvement in a specific context. Nonaka conceptualizes four different modes of knowledge creation based on conversions between explicit and tacit knowledge as shown in Table 3.1.

Table 3.2 Four modes of knowledge creation

To From	**Tacit knowledge**	**Explicit knowledge**
Tacit knowledge	Socialization, which takes place when tacit knowledge is created through shared experience (interaction, on-the job training, apprenticeships etc.)	Externalization, which is the conversion of tacit knowledge into explicit knowledge
Explicit knowledge	Internalization, which is the conversion of explicit into tacit knowledge taking place in 'learning by doing'	Combination, which takes place when explicit knowledge is created from explicit knowledge (re-categorizing, sorting, adding explicit knowledge)

Source: Nonaka 1994

According to Nonaka, organizational knowledge is created when all four different forms of knowledge conversion are managed to form a continuous learning cycle, or spiral. Nonaka emphasizes that organizational knowledge creation is distinct from individual knowledge creation, on which it builds. It is particularly the variety of individual experience and the depth of the individual knowledge that determines the quality of the collective tacit knowledge generated.

The importance of organizational knowledge has been further emphasized by "knowledge management" approaches. The knowledge-based view of the organization rejects the idea of the new institutional economics that firms exist to minimize the transaction costs caused by problems of and inefficiencies in communication. As a result of new information and communication technologies the importance of transaction costs may be reduced to such an extent that hierarchical firms may dissolve into markets of (groups of) self-organizing individuals. According to the knowledge-based view of the organization it is organizational knowledge, particularly in its synergy between tacit and explicit forms, and not transaction costs that holds organizations together, and provides a non-replicable competitive advantage in the market place. (Seely Brown and Duguid 1998). Organizational knowledge constitutes the "core competency", not only of "knowledge firms", but of all organizations. Particularly in the new information economy, concepts of "disintermediation" and "disaggregation" have become widely accepted. Information technologies will make it possible to coordinate activities through self-organizing networks and teams, rather than through formal organizational units.

The role of such informal arrangements, both within and between organizations for the production of knowledge has been discussed in detail by Gibbons et al. (1994). They propose the idea that alongside the traditional mode of knowledge production (Mode 1) a new mode of knowledge production is emerging (Mode 2). Traditional, Mode 1 knowledge is generated within a disciplinary and primarily cognitive context, while Mode 2 knowledge is created in broader, transdisciplinary social and economic contexts. "It is our contention that there is sufficient empirical evidence to indicate that a distinct set of cognitive and social practices is beginning to emerge and these practices are different from those that govern Mode 1." (Gibbons et al. 1994: 3)

The two modes of knowledge production are presented as ideal types where the main differences are that in Mode 1 problems are set and solved by a specific community in an academic context, while in Mode 2 knowledge is generated in the context of application. Mode 1 is disciplinary, homogenous and hierarchical, while Mode 2 is transdisciplinary, heterogeneous and heterarchical. The two modes have different types of quality control and, in comparison with Mode 1, Mode 2 is more socially accountable and reflexive. These points are elaborated in the following paragraphs.

Knowledge production in the context of application implies that a particular problem, not a specific discipline is the object of study. It is an interactive mode with participation of both market and non-market actors. *Transdisciplinarity* has four main characteristics: it develops conceptual frameworks with specific applications in mind; knowledge produced does not usually fit in a specific disciplinary framework, the results are shared with those who have participated in its generation; and it is dynamic in the sense that it emphasizes building problem solving capability.

Mode 2 is characterized by *heterogeneity and organizational diversity.* A variety of people with different skills and organizations participate in studying and solving a problem. The composition of teams changes as the understanding of problems and possible solutions evolves. This process is not planned or coordinated by a central body. Research groups are less institutionalized in comparison with Mode 1: people participate in temporary work teams and networks, changing their participation when problems are solved and new ones emerge. Mode 2 knowledge is thus created in a variety of institutional arrangements: different types of firms, government bodies, universities, and international and national research programs.

Social accountability and reflexivity are important in the new mode of knowledge production and focus specifically on societal concerns about environment, health and other social issues. Accountability is not only related to the interpretation and diffusion of results, but also to the way problems are defined and priorities are set. An expanding number of interests and concerned groups are demanding representation in the setting of the policy agenda and the subsequent decision making processes (Wilsdon and Willis 2004).

Quality control under Mode 1 essentially consists of the peer review process; judgments by individuals who are mostly professional colleagues or competitors. Peer review has both a substantive and a social dimension in that there is professional control over which problems are deemed important and which methods are appropriate. Mode 2 adds application-related criteria on competitiveness, cost-effectiveness and social acceptability.

To what extent such a new mode of knowledge production is already established is difficult to assess. Gibbons et al. have brought together a number of different trends into a new framework and others including Douthwaite (2006) and Wilsdon and Willis (2004) have built upon their insights. Of particular interest with regard to open innovation is the discussion by Gibbons et al. (1994) on inter-organizational forms of knowledge production, referred to as "socially distributed knowledge". The increasing permeability of organizational boundaries is weakening the centralizing tendency of bureaucracy and leads to more decentralized, network types of institutional arrangements. But while decentralization allows research and innovation organizations to be close to their clients, there are also powerful forces encouraging centralization of R&D activities (Albert 1999). Reduction of organizational costs, protection of technological assets, and benefiting from economies of scale and spillovers are important factors behind the process of centralization. In agricultural research and development it appears that the forces of decentralization are particularly strong in public sector research, while centralization processes dominate private sector research efforts.

3.5 Research, technology and innovation in agriculture

The concept of innovation has been around for many years; it plays an important role in economics, in the management literature and in sociology. But for many agricultural research organizations, focused rather narrowly on research, it still presents a challenge. The main reason is that, explicitly or implicitly, many research organizations continue to subscribe to the linear model of innovation that sees a straightforward progression from fundamental to applied and adaptive research, to technology transfer and the adoption and diffusion of innovations. But, while the linear model has been pronounced dead for many years (Turney 1991), it refuses to lie down.

An important reason for this is that, as in many other sectors, the linear model has been "institutionalized", with advanced research done at universities, applied research at public agricultural research organizations, dissemination and technology transfer undertaken by agricultural extension organizations for initial adoption by early-adopting lead farmers and subsequent adoption by the majority of farmers. But in most cases extension and technology transfer activities have been treated as "add-ons" to the research process, which was seen as the main engine driving the broader innovation process in a linear "science push" model.

The relevance of the science push model has particularly been questioned as many agricultural innovations appear to originate outside the formal research system. Innovations are also the result of the active searching and learning behavior of technology users; they are produced by the private sector (particularly through technology embodied in inputs and machinery); and they are heavily influenced by governments through pricing policies and regulatory behavior. The processes that drive a "multiple sources of innovation model" (Biggs 1990) or interactive innovation models will become increasingly prominent as processes of internationalization and market liberalization proceed. Interactive innovation models require that agricultural research organizations which (especially in many developing countries) have been inward-looking public sector bureaucracies become much more open and learn to work with other innovation actors.

These external innovation actors may be other organizations (private or public) in the country or from abroad. For many countries, domestic development of technology – Foster's (2000) "make" option – was particularly prominent during the days when import substitution policies were dominant. The import substitution strategy followed by most developing countries in the 1960s and 1970s led to the building of high tariff walls which promoted domestic investments in production and technology. But, as tariffs have come down, following the subscription to WTO norms, and as ICT and the Internet have facilitated information flows, the options to acquire technology internationally become more important.

Make or buy are not the only options to acquire new technology. Free-riding is sometimes a feasible option as national agricultural innovation benefits from international and intersectoral technological spillovers. This may explain why some countries display good productivity performance despite their low levels of national research investment. In Europe, Italy appears to be a case in point: "One hypothesis in explanation of Italy's scant national research investment in a relatively rich agricultural system is that the country free-rides research efforts undertaken in other sectors and countries […] , taking advantage of the consequent spillover and concentrating limited resources on country-specific programmes and on some phases of the innovation process (especially development)" (Esposti 2002).

International technology acquisition can follow at least four different, not mutually exclusive routes. The first is the embodied technology route, which takes place through the import of capital goods in which the technology is embedded. The second route is the technology licensing or the disembodied route, where firms in developing countries sign a technology collaboration agreement with technology-supplying firms in the developed world. The third route through which technology can be acquired is the Foreign Direct Investment (FDI) route. This appears to be the dominant route for acquiring technology from abroad as developing countries across the world are competing with each other to attract substantial inflows of FDI. Finally, as mentioned, a country can free-ride to some extent on technology produced elsewhere.

Most publicly funded agricultural R&D institutes in developing countries focus on applied and adaptive types of research, though most concentrate narrowly on one or a few types of innovations. A multiple source model of innovation, should be complemented with a "multiple type" of innovation model, and include the following types of activities or functions.

1. Technology generation. This involves the development of new products and processes both in the areas of primary production and of agro-industrial development (processing and marketing). Product innovations include, in particular, the development of new varieties, animal breeds, equipment and agrochemicals. Public sector organizations play a major role in food crops research in developing countries, but the private sector becomes increasingly active, particularly in commercial crops. Process innovations range from simple improvements such as fertilizer application to highly complex processes such as the management of natural resources, integrated pest management, etc. They also include methods and procedures for doing research and development. Agricultural research organizations have concentrated heavily, and rather narrowly, on technology generation. The development of new varieties and the improvement of agronomic practices continue to be seen as the core business of agricultural R&D organizations.

2. Technology acquisition. Many agricultural technologies, in particular those related to high value intensive production, but also the more basic ones, can be adapted well to a variety of local situations. There is evidence that technology spillover effects and economies of scale in plant breeding are much higher than often assumed (Byerlee and Pingali 1994). Similarly, a variety of cultural practices and processes have been transferred successfully across a range of physical and cultural environments. This implies that there is scope for concentration of plant breeding research, and that possibilities for technology acquisition, both nationally and internationally, should receive more attention as efficient ways of promoting innovation. In fact, many international "research" networks involve mainly the acquisition and dissemination of technology. Many agricultural R&D institutes, for various reasons, find it difficult to approach the question of "make" or "buy" in a pragmatic manner and appear reluctant to give a prominent role to technology acquisition at the expense of in-house research. Increasingly, however, in rapidly internationalizing markets for information and technology, and as a result of processes of technical change in developed countries driven by new biotechnology research tools, developing country R&D organizations will need to explore international markets for knowledge and technology much more actively. The collection of information and the "scanning" of the external environment becomes a key issue to facilitate technology acquisition.

3. Technology dissemination. The transfer of technology through extension agencies has been recognized as an important issue in agricultural innovation for many years, because research results can seldom be applied directly. Over the years large sums have been invested in agricultural extension, in technology transfer and in attempts to improve the research-extension linkages (Purcell and Anderson 1997). The most prominent extension approach, the so-called training-and-visit (T&V) system, heavily sponsored by the World Bank throughout Asia was, in the end, declared a failure by the World Bank itself (Anderson et al. 2006). Much of the early technology transfer literature reflects the linear model of innovation as it is seen as the last step before adoption of improved varieties or practices. The consensus that has emerged since the early 1990s, however, has been that farmers are not passive recipients of new technology. Interactive models include a triangular relationship between farmers, researchers and technology transfer and demonstrate the need to involve technology users actively in design and adaptation together with other relevant stakeholders (Merrill-Sands and Kaimowitz 1990, Engel 1997, Sperling and Ashby 2000).

4. Resource conservation. In addition to innovations related to production and processing the issues of resource management and conservation are increasingly demanding the attention of agricultural research and development organizations. This reflects a widespread concern with environmental issues at global and local levels and with the possibilities of maintaining the agricultural resource base to ensure future productive potential of important farming systems. The main issues include the conservation, ownership and valuation of genetic resources, the sustainable use and management of land and water resources, and more recently the impact of climate change. The conservation and utilization of indigenous knowledge is another important issue in many farming systems. Agricultural innovation has focused on a few crops and within those crops on high yielding varieties to the detriment of many locally grown “landraces”, which usually have low productive potential but which may contain a number of important characteristics including specific taste or cooking qualities, adaptation to specific local production environments and resistance to pests and diseases. While there is concern that traditional landraces developed by farmers, sometimes over centuries are disappearing, there is also evidence that modern varieties are replacing land races as a source of diversity and a target of farmer breeding efforts (Salazar et al. 2007).

5. Socio-economic analysis, technology assessment and policy analysis. Changes in the policy environment have a pervasive influence on the feasibility and profitability of new technology. Important factors that affect innovations are changing price regimes, changing markets for inputs, and changes in regulatory regimes as a result of widespread WTO membership. The removal of subsidies and distortionary taxes and the integration in regional and global markets deeply affects prices, markets, and competitive advantage. Many developing countries have also opened up the markets for seeds, other inputs and equipment to the national and international private sector, which increases choice for the farmers, but which may threaten biodiversity. Changes in regulatory regimes related to intellectual property and biological and food safety will have major effect on the process and patterns of technical change.

Most public agricultural R&D organizations in developing countries are ill prepared to address these challenges. Their capacity for assessing the impacts of new technology and the implications of changing policy environments for agricultural innovation is quite limited. This may have serious impact on the relevance and effectiveness of the technologies being developed.

3.6 Conclusions

Even though it is evident from the literature that innovation is a non-linear, interactive process, driven by developments in science and technology as well as by those in markets, most research organizations, including those in agriculture, are still organized along the lines of the linear science and technology push model. They position themselves somewhere along the basic-adaptive research continuum and maintain linkages upstream with “advanced” research institutions and laboratories, and “downstream” with organizations that apply research results. Gibbons et al. (1994: 159) argue that a new type of integrated innovation policy is needed, replacing separate science, technology and innovation policies. They attribute the limited success of such new types of innovation policies to the fact that “…the presuppositions of older science policies linger on and continue to structure the thinking of policy analysts and decision makers”.

The main conclusions with regard to innovation may be summarized as follows:

1. Research is neither a necessary, nor a sufficient condition for innovation. Even applied research activities do not automatically lead to innovation. At the same time as Dosi (1982) observed: the science and technology base for innovations is increasing rapidly. New technologies and innovations may be developed in-house, but increasingly they may be acquired (licensed, bought, or borrowed) from other organizations. They may be developed as a result of scientific breakthroughs, or they may be developed in response to specific market demands.

2. There are many sources of innovation, both within and between different types organizations of organization. Agricultural innovation processes become increasingly international. Private sector led agricultural innovation is increasingly a small numbers game as it is concentrated with a small number large agro-food, seed and life science companies. Public sector agricultural innovation involves a much larger number of actors.

3. By now it is conventional wisdom that innovation is an interactive process that involves a variety of different actors and that may be induced by different factors in the broader economic environment and by developments in science and technology. Still, the linear innovation model refuses to fade away. The study of specific innovation processes benefits from an actor-based perspective to allow a detailed assessment of the different sources of innovation as well as the interactions that take place between the actors involved.

4. Learning processes at individual, organization and inter-organizational levels are the key to understanding how interactive innovation processes work through trial and error, and experimentation. As agriculture becomes increasingly knowledge-intensive, learning becomes the core skill for research organizations to sustain their long-term capacity to innovate.

5. Shifting from a research to an innovation approach has important implications for the management, organization and governance of research organizations. They will need to develop the capacity to establish, maintain and benefit from linkages and partnerships with other innovation actors in open, network type of organizational arrangements

6. Finally, innovation also needs to be seen as a strategic process that can be actively supported by governments through a variety of policies, but which requires other actors from public and private sectors and from civil society.

4. Institutions and the governance of innovation

4.1 Introduction: institutions and innovation

The technical change and innovation processes discussed in chapter 3 do not take place in a vacuum. Innovations take place in a selection environment, defined broadly as the institutional framework which includes markets, governments, laws and regulations, as well as knowledge and dominant designs (McKelvey 2001, Nooteboom 2004). The institutional framework that forms the selection environment is critically important for organizations that do research and produce innovations. There is broad consensus that technical and institutional innovations influence each other, and that technologies and institutions co-evolve (Radosevic 1998). As Nelson (1995: 80) has put it: "…to be effective with those technologies a nation requires a set of institutions compatible with and supportive of them."

The importance of institutions for agricultural innovation was emphasized by Byerlee (1998) as the main constraint on the performance of agricultural research organizations. Byerlee et al. (2002) stress the need for a conducive research environment and contrast the progress made in the area of technical innovation with the limited progress in institutional change. The challenges they formulate for public research organizations to improve their performance are of an institutional nature and include the increasing importance of new policies on IPR, the need for pluralistic organizational structures, the separation of funding and execution of research, the need for public research organizations to focus on the production of public goods, the complementary nature of public and private research, stakeholder participation in setting the research agenda and the need for new models of technology transfer.

Similarly, the research discussed in chapter 3 suggests that innovations in agriculture, rather than passively induced by relative resource endowments and factor scarcities (Hayami and Ruttan 1985), are introduced and adopted through a process where institutions play an important strategic role (Tabor 1997). Institutions are important for directing and guiding technical change. As the technical change process becomes more complex, innovations in institutional arrangements and governance mechanisms are needed. Many governments have realized this and have put in place technology and innovation policies to speed up the pace of technical change. New policies, however need to be supported by new and innovative institutional frameworks and governance structures to achieve technical change (Rodrik 1999).

The purpose of this chapter is to analyze the role of institutions in providing governance for agricultural innovation. Following the introduction of the importance of institutions in this section, the following section (4.2) presents the main concepts of institutions, organizations and governance, and their relations to innovation processes. Section 4.3 analyzes the relationship between institutions and governance, which can be analyzed at a number of different levels (Van der Steen 1999). The emergence of global and international institutions was discussed in chapter 2 (section 2.4). Here the focus is on institutional change at three levels. At the national or macro level institutional development since the 1990s has been shaped by ideas of the New Public Management (NPM) and the New Institutional Economics (section 4.4). Institutional issues at the level of the organization ("corporate governance") are presented in 4.5. At the meso level of institutional development the governance of networks has emerged as an important topic, which is analyzed in section 4.6. Section 4.7 draws conclusions[9].

4.2. Institutions, organizations and governance

4.2.1 Concepts, issues and debates

To some authors (Clague 1997: 18) institutions can be many different things:

> "They can be organizations or sets of rules within organizations. They can be markets or particular rules about the way a market operates. They can refer to the set of property rights and rules governing exchanges in a society. (The individual actors that are constrained by the rules may be organizations and, indeed, frequently are). They may include cultural norms of behavior. The rules can be either formally written down and enforced by government officials or unwritten and informally sanctioned."

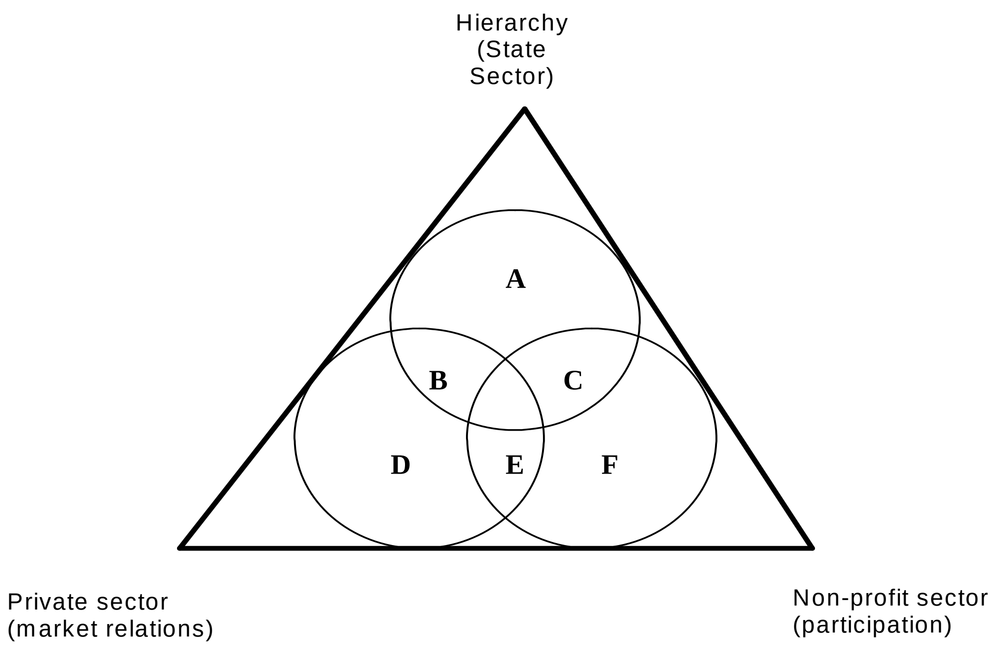
Others, such as North (1995) clearly distinguish between institutions and organizations. Institutions are the "humanly devised constraints that structure human interactions". They are "the rules of the game". By contrast, organizations are the players: groups of individuals bound by a common purpose to achieve objectives. Institutions can be formal (laws and regulations) or informal (conventions and norms). Organizations include political bodies (parties, city councils, regulatory agencies), economic bodies (firms, cooperatives, family farms), social bodies (churches, clubs) and educational bodies.

Williamson (1996) follows North's definition of institutions as "rules of the game", which operate at the contextual level of the institutional environment, but stresses the importance of three types of "institutions of governance": markets, hierarchies, and hybrids. The institutions of governance as defined by Williamson can be seen as three basic "organizational models" in which the individual transaction is the basic unit of the analysis. While it may seem that this straightforward definition of institutions and organizations should provide conceptual clarity this has hardly been the case. There are a number of reasons why the distinction between institutions and organizations remains problematic.

While the definition of "organization" is relatively clear, "…the concept of 'institution' remains one of the fuzziest in social sciences" (Goldsmith 1993)[10]. In a broad sense of "behavioral rules" institutions e.g. in agriculture include land tenure, share cropping arrangements, credit organizations, markets, intellectual property etc. This is the main reason that the NIE has covered such a wide variety of issues and problems and is using a similarly broad set of concepts. Because of the lack of clarity of the concept of institution and the confusion in terminology, most of the empirical research and literature fails to distinguish the two concepts properly.

Figure 4.1The societal triangle

[9] These different levels correspond to a large extent with the distinction between hierarchies, networks and markets presented below.
[10] Goldsmith (1993) refers to "rule oriented" and "role oriented" institutions.



	Nature of Project Goods	Dominant Parameters	Institutions	Examples
A	Government	H	State Agencies	Quarantine services Research
B	Toll	M, H	Public or regulated private corporations	State-owned enterprises, Public-private partnerships
C	Public	P, H	Hybrid organizations	Education, extension, rural infrastructure
D	Market	M	Private corporations, farmers, and entrepreneurs	Commercial farming, industry, services
E	Civil	P, M	NGOs, PVOs	Subsistence farming, Rural development organizations
F	Common pool	P	Local organizations, cooperatives	Farmer organizations, Cooperatives

Parameters: Hierarchy = H; Participation = P; Market = M

Source: adapted from Picciotto 1997, van Tulder 2006

A second reason why the institution-organization distinction is sometimes confusing is that the two have a symbiotic relationship (North 1991). Usually, institutions and organizations are directly linked "since organizations cannot work without rules and rules are often enforced by organizations" (Goldsmith 1993). As a result, the discussion and practice of "institutional development" often lacks clarity: "Technical agencies in developing countries have often been hazy about which kind of institution - more efficient rules or modern organizations - they hope to strengthen when they support institutional development projects" (Goldsmith 1993).

Picciotto (1997) and van Tulder (2006) elaborate on Williamson's three modes of governance framework by illustrating the variety of different institutional arrangements and modes of governance as three ideal types and three mixed types resulting from the interaction of state, market and non-profit actors. Their analyses relate the types of goods produced by organizations with different institutional design parameters. The model presented in figure 4.1 involves the public, the private and the non-profit sector as pure types, producing state goods, market goods and common pool goods. In addition, a number of intermediate type goods are produced: public goods (between state and voluntary sector), toll goods (between public and private), and civil goods (between market and non-profit sector). The model is relevant for the design of institutional mechanisms in agricultural innovation systems that involve the production of a variety of private, state, public and common pool goods. As such, Picciotto's basic model shows that a focus on pure public goods, as advocated by Byerlee et al. (2002) may not be the most effective way of generating innovation. Another implication of the triangle model is that innovation (seen as the production of new goods often at the interface of private, public and voluntary sectors) involves a variety of actors and requires an interactive process.

4.2.2 Why is institutional change so hard to achieve?

If institutions form an important constraint on creating new products and services (i.e. innovation) it is important to ask why this should be the case. Transaction cost economics (TCE) provides an explanation of the question why institutional change is difficult to achieve. The argument starts with Coase's (1998) original question as to why firms choose to undertake some activities themselves, while leaving others to the market. TCE suggests that the outcome of "make" or "buy" decisions that firms have to take depends on the transaction costs. Transactions include the exchange of goods, services and information among individuals and organizations. Transaction costs arise because usually there is uncertainty and asymmetry in information between the different parties in a transaction. Whereas neo-classical economics assumes that behavior is rational ("hyperrational" in Williamson's terms), transaction cost economics assumes that behavior is "intendedly rational but only limitedly so" – "bounded rationality" in Williamson's terms. Transactions take place within and between organizations, and transaction costs determine whether a good or service will be produced "in-house" or procured from the market "Make or buy" decisions have important implications for the way organizations function and for the ways in which they interact with their environment.

If a decision is made to undertake an activity in-house, investments will have to be made by the organization. The degree to which these investments (assets) can be redeployed to alternative uses, without sacrifice of productive value, has become known as "asset specificity" (Williamson 1996: 59). For example, if an agricultural research organization decides to expand its activities into new areas, such as molecular biology, investments will have to be made in specialized equipment and laboratories that conform to biosafety regulations. As it will be difficult and costly to put these investments to alternative uses, they will determine the organization's activities for a long time. This is the notion of "path dependence", which explains why established organizational structures and activities tend to survive and why organizational change is costly and difficult to achieve.

> "Institutional path dependence exists because of network externalities, economies of scope and complementarities that exist with a given institutional matrix. In everyday language the individuals and organisations with bargaining power as a result of the institutional framework have a crucial stake in perpetuating the system." (North 1995: 20).

Asset specificity comes in a variety of forms, including site specificity, physical asset specificity, human asset specificity and dedicated asset specificity – investments made on behalf of an individual client (Williamson 1996). In addition to path dependence, asset specificity also creates bilateral dependence between parties to transactions, which has specific effects on the configuration of institutional and organizational arrangements[11].

The concepts of path dependence and asset specificity help to explain why there are rational reasons for large organizations to choose inertia or to become dependent on one particular evolutionary path. For many traditional public sector research organizations and systems it is a major challenge to change the way organizations are governed.

4.3 Governance and institutions

The "institutions of governance" provide a framework of laws, rules, and customs that guide behavior of actors and the interaction between them. Governance as a concept is clearly linked to that of government. It has become popular since the beginning of the 1990s. The governance concept has been used in at least six different ways (Rhodes 1996):

- Governance as the minimal state
- Governance as corporate governance
- Governance as the new public management
- Governance as "good governance"
- Governance as a socio-cybernetic system
- Governance as self-organizing networks.

An important reason why the concept of governance has become popular in the public sector appears to be that the idea of governance is broader than that of government (Stoker 1998). Often, the notion of governance is used to present new ideas of public sector management, using models that emphasize the involvement of partners from beyond the public sector. Like Rhodes, Stoker finds that the academic literature is fragmented and originates in a variety of disciplines. "The contribution of the governance perspective to theory is not at the level of causal analysis. Nor does it offer a new normative theory. Its value is as an organizing

[11] Williamson distinguishes four types of adjustment or adaptation to change: strictly autonomous, mainly autonomous, mainly coordinated, and strictly coordinated.

framework ... The governance perspective works if it helps us identify important questions, although it does claim to identify a number of useful answers as well" (Stoker 1998: 18). He then presents five propositions on governance:

1. Governance refers to a complex set of institutions and actors that are drawn from, but also beyond government.
2. Governance identifies the blurring of boundaries and responsibilities for tackling social and economic issues.
3. Governance identifies the power dependence involved in the relationships between institutions involved in collective action.
4. Governance is about autonomous self-governing networks of actors.
5. Governance recognizes the capacity to get things done, without relying on the power of government to command or use its authority. It sees government as able to use new tools and techniques to steer and guide.

The following sections review in detail different governance approaches at three levels of analysis: the national or macro-level, sometimes referred to as political governance, the intermediate level or network level of governance, and at the micro-level "corporate" governance.

4.4 National level governance

The analysis of governance issues at the national level addresses, amongst others, the role of the state, the civil service, organizations and the relationship between government and citizens and has been studied most extensively in political science and public administration. Public administration as a discipline evolved in the U.S. at the end of the 19th century as a reaction to the problem of corruption in American government. Woodrow Wilson directly linked the elimination of corruption to the introduction of effective administration. He argued that a "science of administration" would be needed to improve the management of the public sector, emphasizing the separation of the implementation of policies from the political decisions that created those policies. Max Weber argued that, as society became more complex, it would need more complex institutions and a change from informal, personal organizations to formal bureaucracy – organized along hierarchical lines – would be required (Behn 1998).

Public administration has studied how organizations function in society and has addressed a wide variety of problems including the provision of and access to public services, civil service reform, the design and implementation of public policy (Najam 1995), public expenditure management (Premchand 1993), decentralization (Cohen and Peterson 1997), and the problems of inter-organizational coordination.

Early approaches to public administration focused on a simple distinction between a steering body (state bureaucracy) and a steered system (implementing agencies). More recent approaches in the public administration literature, in a reaction to this simplistic dichotomy, emphasize the interaction between the two, and allow for a larger number of participating organizations, or stakeholders in the process. Most of the recent public administration literature is concerned with the changing role of government in society, policy implementation and evaluation, decentralization and the trend towards pluralism. From a public administration perspective, governance is very much about the ways in which clients and stakeholders are involved in the policy and strategic direction of organizations.

Rhodes (1996) argues that governance is broader than government and his "new governance" specifically emphasizes that in open and complex societies government is one of many players. Taking a systems approach, governance can be seen as the outcome of government interacting with other parties. "In other words, policy outcomes are not the product of actions by central government. The centre may pass a law but subsequently it interacts with local government, health authorities, the voluntary sector, the private sector and, in turn they interact with each other. [...] There is order in the policy area, but it is not imposed from on high; it emerges from the *negotiations* of the several affected parties" (Rhodes 1996: 657, italics in original).

Interactions between government and society are seen as the core of modern governance in public administration (Kooiman 1993, 2000). Interactive forms of governance are needed because society is becoming more complex, dynamic and diversified and no single actor, public or private, has all the knowledge and information to deal with these highly complex problems involving a variety of different organizations. Co-steering, co-management, negotiation and bargaining then become important strategies for governance; and communication between multiple actors is an essential condition for success and learning in self-organizing networks.

Three schools in particular have contributed to the debate on the relationships between the institutions of governance and the interactions between government, private sector and civil society: the New Public Management (NPM), the New Institutional Economics (NIE), and the "Good Governance" school.

4.4.1 Steering through vision: the New Public Management

The traditional public administration model has proven to be neither very efficient nor non-political. Weber's bureaucracies are no longer seen as effective instruments in the achievement of government objectives. Specialization requires the breakdown of work in a large number of tasks and the structuring of activities along vertical lines, requiring costly coordination. "Bureaucracy", in common language, has become a byword for inefficiency. In addition, it has proven impossible to separate administration from policy making and politics. Implementation, it turns out, is inherently a political process (Behn 1998, Najam 1995, Brinkerhoff 1996).

The public administration model sought to cure the problems of corruption that plagued government at the end of the 19th century. More than a century later governments in Western democracies appear to be less affected by problems of corruption than by problems of performance. The New Public Management (NPM) School [12] has emerged as a response to the inadequacies of the traditional public administration model and explicitly seeks to address the problems of government performance (Lynn 1997) and more broadly of governance (Kettl 2000). In many ways the NPM is more than a school – it has become a strong and activist movement, which advocates its ideas in an outspoken manner and through a variety of media[13]. Ever since the publication of "Reinventing Government" (Osborne and Gaebler 1992), the ideas of the NPM have been promoted vigorously by a variety of actors. The NPM is based on two important premises:

- Public sector managers hold an obsolete (bureaucratic) model of the world (Frant 1996). In the words of Osborne and Gaebler (1992: 331): "[T]he lack of a vision – a new paradigm – holds us back."
- The "reinvented" government is smaller and concerned with "steering" rather than "rowing". Policy implementation and service delivery tasks (the rowing) are delegated or subcontracted to newly created or privatized agencies.

In practice the NPM aims to introduce private sector management ideas and methods into public sector organizations in order to improve their performance (Kaul 1997). Whereas the traditional public administration approach emphasized the separation of politics and administration (the latter being the responsibility of a civil service bureaucracy), a key idea in the NPM is further separation of policy making and implementation and opening up the latter to competition.

The NPM emphasizes professional management, performance standards, achievement of results, and a client ("customer") orientation. The ideas of the NPM are discussed below in some detail, as they have been very influential in policy circles. They are also relevant for agricultural research and knowledge organizations, traditionally funded almost exclusively by the public sector, but increasingly facing the challenges of reorganization, the introduction of new management systems, privatization, and the introduction of competition for funding.

The ideas of the NPM have shown their influence both at the national level of government and the level of individual agencies or organizations where services are delivered. Six issues are mentioned frequently in the literature (Kaul 1997, Kettl 2000):

1. Improving service provision. A major concern of the NPM has been the improvement of public service delivery to the general public. Quality, timeliness, choice, consultation, information, courtesy, value for money, and an effective complaints system are key elements of improved service to the public. Increasingly, performance targets are part of contracts either between organizations or between organizations and staff. Decentralization of service provision is often introduced to improve delivery.

[12] The new public management is also referred to (particularly in the U.K.) as the "new managerialism".
[13] The OECD, the International Public Management Network, the World Bank and a number of national governments actively promote the ideas of the NPM on the Internet and by other means.

2. Improving productivity by introducing competition. Privatization, deregulation and "marketization" have been introduced to improve clients' choice by increasing the numbers of suppliers, by reducing the "barriers to entry" and the "barriers to exit". Alternative mechanisms include contracting out the provision of goods and services under competitive bidding procedures and promoting competitive funding mechanisms to obtain grants or subsidies (Israel, 1987, Tabor et al. 1998).

3. Measuring, benchmarking and evaluating performance. The introduction of performance standards, their measurement, their comparison across institutes and their use to reward or punish performance have become widespread. In the U.S. the Governance Performance and Results Act required all public sector organizations to develop performance plans. The search for output-oriented performance indicators and performance assessment systems has also become common (Peterson 1998) and the evaluation of performance is seen as a key instrument to improve accountability for results.

4. Improving financial planning and control systems. In general, the reforms that are part of the NPM have aimed to bring public sector conditions and practices closer to those of the private sector. If managers within the public sector are to be responsible for performance they will need both the tools and the information to deliver the results demanded. Kaul (1997) discusses three mechanisms: output-oriented systems especially in budgeting and expenditure management, accrual accounting to provide better cost information on goods produced and services delivered, and the realistic charging of capital cost including the use of depreciation.

5. Improving personnel management. Flexibility in staffing, open recruitment procedures, promotion based on merit and achievement rather than seniority, setting performance targets for staff, linking remuneration to performance, encouraging entrepreneurial behavior, and recognizing achievement in a variety of ways are important instruments in the NPM.

6. Changing organizational structure. Changes in organizations are needed to ensure that these are aligned with performance goals and with the controls to facilitate the achievement of the organization's mission. Common recommendations are to create organizations that are *vertically flatter* (to improve internal decision making and reduce response time to clients), *less formalized* (to empower staff) and horizontally *more complex* (linkages with multiple clients).

While the ideas of the NPM have found strong support in government agencies, international organizations and with an army of management consultants, the academic literature has been much more critical (e.g. Dixon et al. 1998). The main issues that are debated in the literature relate to content, process, organizational models, tools, behavior, legitimacy and accountability.

- ***Content.*** The NPM is criticized for presenting little that is new, ignoring the differences between public and private sector, and, in fact, introducing outdated Taylorist private sector management practices into public sector organizations (Dixon et al. 1998).
- ***Process.*** The NPM focuses on the management and implementation of policy, rather than on policy design and development. It stresses effectiveness, efficiency and quality

over process and equity (using performance measurement, benchmarking and related tools). It seeks to diffuse responsibility and devolve authority and shifts the accountability focus from inputs and process to outputs and outcomes. It attempts to insert competition and private sector management practices into the public sector. Under managerialism "[t]he management of the public "production process" is thus best de-coupled, as far as possible, from political structures and processes and best left not to self-seeking and empire-building bureaucrats[...], but to cognitive, goal-oriented, problem-solving, decision-making and interventionist technocrats." (Dixon et al. 1998)

- ***Organizational models.*** A basic NPM principle is that public sector problems can be cured by private sector medicine. If it is true, however, that today's complex societal problems require innovative institutional arrangements and new organizational models, it follows that a simple introduction of private sector management procedures will not work. Authors from both the public administration tradition (Kooiman 1993) and from the new institutional economics (Williamson 1996) agree that new organizational models require their own set of rules and instruments.
- ***Tool availability.*** The validity of the NPM critically rests on the assumption that there is, in the private sector, a large body of knowledge, management practice and tools that can be readily transferred to the public sector. This assumption rarely holds because public and private sector organizations are indeed different. Even though the two types of organizations may show structural similarities, they have different purposes and they are different in the ways they interact with their external environment, in the way their accountability systems operate, and in the way they manage their internal processes, such as planning and budgeting. Because public and private sector organizations are so different, it is difficult to transfer and replicate private sector decision-making tools.
- ***Behavior.*** Dixon et al. (1998) assert that the NPM has an "economistic" underpinning, particularly found in the new institutional economics which attributes "rent seeking" behavior to civil servants but not to corporate entrepreneurs and which proposes a variety of solutions in the form of privatization, corporatization, and commercialization without sufficient justification or evidence. According to Dixon et al. (1998) the NIE is concerned with opportunism in public administration: self-serving, rent-seeking, even dishonest, behavior by bureaucrats, their clients and politicians which results either from the uncertainty of incomplete contracts, or because principals cannot effectively monitor the behavior of their agents. The result is an inherent tendency for such bureaucrats to make and implement policy decisions in such a way as to promote their own self-interest.
- ***Legitimacy.*** The NPM focuses on the improvement of effectiveness and efficiency, but public management is not only a question of efficient delivery of the right services, it is also a question of legality and legitimacy. In a democratic society, certain rules and procedures have to be followed and these may well conflict with the introduction of business-like practices. The NPM tends to view citizens as "customers". Where government has a service delivery role, a customer perspective may definitely improve the quality of service. But in other respects, however, there are fundamental differences between being a citizen and being a customer.
- ***Accountability.*** Some authors have argued that there is a possible conflict between the NPM's emphasis on performance and the accountability to clients and stakeholders. Privatizing public sector tasks may well leave them in the hands of unaccountable

private or quasi non-governmental organizations that may be accountable to their direct customers, but may lack a broader “democratic accountability” to government and the general public (Behn 1998). Perhaps not surprising, the problems encountered in many privatization and deregulation schemes have indicated the urgent need for re-regulation of the deregulated agencies and organizations.

4.4.2 Steering through incentives: the New Institutional Economics

The fact that everyday life contradicts some of the basic assumptions of neo-classical economic theory has concerned a number of prominent economists who have sought to replace, amend or extend the dominant paradigm. These concerns have been addressed in particular in the New Institutional Economics (NIE). The most important traditional neo-classical assumptions that are relaxed in the NIE are those of costless exchange, perfect information, and unlimited cognitive capabilities (North 1991).

While some of the insights of the NIE have found their way into the thinking of the NPM, a comparison between the two shows striking differences as well. While the NPM has been “unashamedly normative” (Frant 1996) in telling managers how to make organizations work better, the NIE has tried to answer the question of why institutions behave as they do[14]. In this way, it has focused on the incentives that institutional decision-makers face, the operating environment for institutions, and the evolution of different institutional practices. The NIE with its emphasis on incentives comes from a positive perspective and studies how organizations actually behave. By contrast, the NPM, from its normative perspective, argues that the problem is not so much one of incentives, but rather one of outmoded ideas and a lack of vision.

The different “branches” of the NIE include a variety of approaches dealing with transaction costs, imperfect information, property rights and collective action. Under the rubric of NIE, different economists have tried to take into consideration asymmetric and imperfect information, rent-seeking behavior, political voting regimes, transaction costs, principal-agent relationships and the role of voice and exit mechanisms in guiding policy making processes.

At the micro level, transaction cost economics states that “the transaction is the basic unit of analysis and regards governance as the means by which order is accomplished in a relation in which potential conflict threatens to undo or upset opportunities to realize mutual gains” (Williamson 1998: 76). Different types of contractual arrangements are used as instruments governing the interaction between actors with regard to specific types of activities.

At the macro level, the NIE has explored the links between political regimes, economic performance and governance. There is evidence that democratic and pluralistic societies are better at providing secure property rights than autocracies (Clague et al. 1997). The literature also suggests that democratic systems are better at empowering local organizations through participation. Pluralism is an important element in governance and political systems. It implies that citizens can make choices. The NIE has explored the different uses of “exit”, “voice” and “loyalty” as strategies or options in principal-agent relationships providing

[14] Other authors have stressed that the NPM has borrowed considerably from the NIE (Dixon et al. 1998).

powerful concepts in the analysis of governance, accountability and participation. The "exit" option is linked to market modes of operation and essentially presents the possibility for customers to take their business elsewhere if dissatisfied. Voice mechanisms require participation and are important to restore confidence. Without a credible exit option, however, they are relatively ineffective, which is why contracts contain detailed clauses on when and how voice and exit mechanisms can be used (Williamson 1996). "Loyalty" is seen as an exit-postponing mechanism; it is activated by leadership and relies mainly on hierarchy. Loyalty mechanisms are used when exit needs restraint to benefit fully from the recuperative benefits of voice (Picciotto 1997).

Property rights and contractual relations are a key concept in the NIE – to the extent that some authors have defined the NIE as the economics of property rights. The NIE holds that property rights are problematic, in contrast to neo-classical economics where it is assumed that property rights are easy to define and enforceable at negligible cost (Williamson 1996). Property rights include an individual's right to use, rent, sell, destroy, modify, donate, and transform property and the ways in which the rights of some parties to treat their property affects the rights of others (Clague 1997). The NIE literature emphasizes that a variety of property rights can be reasonably efficient, as long as the rights are clearly defined and can be transferred by entering into contracts. Major problems arise when property rights are unclear and the markets to trade property are underdeveloped.

The importance of property rights for development has been elaborated by De Soto (2000). Most poor people, he argues, own property, but since their right to that property in the informal sector can normally not be confirmed, it cannot be used as equity or as collateral for investment purposes. De Soto argues that lack of (access to) property rights is the main reason "…why capitalism triumphs in the West and fails everywhere else".

There are four reasons why property rights are increasingly relevant for agricultural development and innovation: increased scarcity of resources, increased specialization, increased knowledge intensity, and the growing role of the private sector in agricultural research and development. Property rights are relatively unimportant when resources are abundant and become more prominent when resources are scarce and expensive. With a decline in the quality and quantity of the natural resource base for agriculture, caused by population growth, erosion, urbanization and other factors, property rights, particularly over land and water, become highly contentious. With innovation, agriculture becomes more knowledge intensive and specialized with regard to inputs, processes and outputs. Specialization results in the establishment of new organizations that undertake specific tasks and that require the establishment of clear property rights regarding the goods or services that they provide. Specialized providers of knowledge increasingly rely on the protection and commercialization of their (intellectual) property to survive and prosper.

Some have argued that the NIE has developed a theory of the state or even a "grand theory of development" (Harriss et al. 1995). But unlike the NPM, which has produced a number of clear guidelines for managers, the NIE, with its emphasis on description rather than prescription, has not produced similar simple recipes. In fact, practitioners have often found it difficult to translate the insights of the NIE into practical policies. With regard to the governance of organizations and networks, discussed later on, the NIE has, however, made a number of important contributions. These relate in particular to the role of incentives, and the relationships between “principals” and “agents”.

The NIE is based on two main behavioral assumptions (Williamson 1996): bounded rationality (discussed above in the context of transaction costs), and opportunism, which is a basic concept in principal-agent theory, another branch of the NIE. In a principal-agency relationship, a principal delegates some rights to an agent who is bound by contract to represent the principal’s interests in return for payment (Eggertsson 1990). Agents usually have more knowledge of the details of the tasks to be performed than the principal. Because of opportunism agents they will tend not to perform in the manner agreed, but to shirk their responsibilities and duties, a problem known as “moral hazard” (Hodge et al. 1996). Klitgaard (1997: 296) sums up a number of the problems with agents: they “…distort activities towards those things measured easily at cost of those things not easily measured, .. [they] engage in influence activities: distorting information, influencing evaluators of information, not revealing useful private information …. agents may avoid useful teamwork or even sabotage others.” Principals try to deal with this through the introduction of appropriate contracting and monitoring mechanisms. There is a tendency in the NIE to emphasize the opportunism of agents, but principals have their own ways to achieve desired behavior in agents, including “moving the goal posts”.

Contracting is important in the NIE to “get the incentives right”. Principals try to protect their interests by designing contracts of a different type. Performance (or outcome-based) contracts relate rewards and compensation to measurable outcomes – these can be the number of units produced, profit, or stock price. “Outcome-based contracts are used when there are large differences in goals between owners and managers, when behavior on the job is difficult to monitor, and when outcomes are easily measured” (Hodge et al. 1996). Behavioral contracts prescribe appropriate conduct: e.g. the implementation of certain duties. Behavioral contracts are most appropriate when the desired outcomes are unclear or difficult to measure, when tasks are fairly routine and when the extent of goal conflict between principals and agents is not too great.

The NIE attempts to better understand the incentives that leaders of institutions face. Olson (1997: 40) defines institutional incentives as “inducements to self-interested action that face those with power”. For those with power, rational self-interest can take many forms. In private firms, profit maximization is often a good proxy for what drives leaders. In public organizations, it could be the accumulation of power and authority, the collection of economic rents, protection of a segment of bureaucratic turf or simply the satisfaction gained by serving clients efficiently and effectively. The NIE literature finds that attempts to reform institutions need to be consistent with the incentives facing institutional leaders. But while there appears to be consensus on the importance of getting incentives right, their link to improved performance is tenuous. “If skewed incentives are a problem, why aren’t better incentives a solution?” (Klitgaard 1997: 301).

Performance management requires some degree of supervision. Austin (1996) suggests that there are three options: no supervision of agents, full supervision and partial supervision. The alternative to full supervision – which is usually exceedingly costly for the principal – is partial supervision, in particular through the provision of incentives to steer agents towards desired behavior, and by relying on competition, rather than on planning and coordination.

In his influential book “Institutional development – incentives to performance”, Israel (1987) discusses a number of “standard” factors that have been used to explain low levels of institutional development and performance: the importance of leadership by outstanding individuals, the need for good planning and careful preparation, the use of appropriate management tools and approaches, the perverse effect of distorted prices, the need for political commitment to institutional development, and the importance of exogenous factors such as war and natural disasters. Israel finds that these traditional “success factors” are necessary, but not sufficient and proceeds to discuss in detail the importance of “task specificity” and “role specificity” and the need to create competitive mechanisms in enhancing the performance of organizations[15]. Specificity and competition provide strong incentives to individuals and organizations to improve performance.

Specificity relates to internal incentives and competition to external incentives. Activities and tasks differ greatly in the extent to which they can be specified. The more an activity can be specified, the clearer and more operational its objectives will be, with a specific time-frame, and well described methods. Task specificity is also crucially important for monitoring and control.

Israel then presents another idea that has become widely accepted: the introduction of competition and competition surrogates; the latter being mechanisms that can be used when full market competition is not feasible or desirable. Competition refers to the provision of similar goods or services by alternative suppliers. Pseudo competition requires external pressure from clients, suppliers and beneficiaries, or from regulatory agencies. It may also involve the creation of internal competition between different units of an institution. Although competition does not always work, and can be perverted, it is generally seen as a powerful mechanism to improve the performance of organizations. In many areas, including agricultural research and innovation, competition is becoming increasingly common as the private sector and the voluntary sector become more prominent players in the field. At the same time, there has been a rapid increase in the number of competitive funds, competitive programs, as well as the introduction of more competition in recruitment and remuneration policies.

But just as the measurement and assessment of performance through the use of indicators may have unintended consequences, so has the introduction of competition experienced its own dysfunctionalities and unexpected problems. Privatized utilities in Europe and the USA have not always brought the expected combination of lower prices and better service, but have created private oligopolies where public monopolies existed. Similarly, the introduction of competition in research through competitive funds has proven difficult to manage by the principal and costly for the agents who have to spend significant resources in acquisition and proposal preparation.

[15] Israel was one of the first authors to link institutional development explicitly to performance.

While both performance targets and competitive mechanisms hold significant promise (particularly when used in combination), the potential benefits will only be realized if rules of the game are exactly right in encouraging the desired behavior and producing the right mix of competition and coordination. The "fine print" is usually contained in "performance contracts" established between principals and agents. These are a powerful instrument to steer behavior in a specific direction, but to be successful they need extraordinary amounts of experience and skills.

4.4.3 Good Governance?

Institutional and governance problems have been widely identified as a key obstacle to economic and social development: "Institutions Rule" (Rodrik et al. 2002). The idea of "good governance" can be seen as an eclectic combination of elements from the public administration tradition, the NPM and the NIE. Good governance has become associated with efforts to strengthen the rule of law and the legal framework for development, improved public sector management (accounting, public expenditure management, and civil service reform), improved transparency and accountability in public sector activity, and the elimination of corruption (OECD 1997, The Economist 2008).

A broad variety of issues have been covered in discussions of good governance: participatory approaches to development, human rights and the level of military expenditures. The World Bank (1994) has identified three aspects of governance: first, the type of political regime; second, the process in which authority is exercised in the management of a country's economic and social resources for development; and third, the capacity of governments to design, formulate and implement policies and discharge it functions. The World Bank explicitly states that it focuses on the second and third aspects of governance as the political aspects are outside its mandate.

International donors have a strong interest in good governance and the rule of law, which are seen as important conditions to guarantee the sustainability of development efforts. Without a good governance framework, it is argued, the effectiveness of individual project and program investments is highly uncertain. The rule of law and the legal framework for development, are seen as vital in guaranteeing property rights, human rights and limiting the power of the state. Judicial reform programs have been implemented in a large number of developing and transition countries aimed at improving the rule of law. In the promotion of the rule of law transparency and information are major topics. Transparency is crucial in market oriented reform programs of privatization and liberalization. It is also highly important in the public sector if authoritarian styles of government are to give way to more open, democratic systems. Yet, despite the fact that rule of law studies are booming, Carothers (2003) has argued that our actual understanding of the idea of rule of law at the different levels of concept, operations and effects remains very limited.

In its review of governance activities carried out in the early 1990s, the World Bank (1994) discusses a number of specific experiences and some broader concerns. The specific issues relate to public sector management where civil service reform, financial management, and reforms of the state enterprise sector are key elements. A discussion of the demand for more accountability is presented and "macro" level accountability – which is hierarchical, reporting upwards to the political level – is distinguished from "micro" level accountability to stakeholders, involving mechanisms of participation, decentralization and competition. The focus of accountability appears to have shifted from the use inputs to results or the production of outputs. The literature attaches a high degree of importance to accountability as a way of operationalizing good governance. Organizations can only be held accountable if their objectives and tasks have been well specified: a prime responsibility of the governing body. In many public sector organizations unclear and overlapping objectives are a sign of inadequate governance.

In assessing the theory and praxis of good governance attention focuses on the public sector, which is mainly where "bad governance" is assumed to be located. The introduction of participatory development has included the voluntary sector and civil society more explicitly in the analysis, but the role and governance of the private sector and the development of innovative new governance mechanisms receive little attention.

As with many ideas promoted and activities sponsored by donors, and particularly by the World Bank, the concept of good governance has drawn considerable criticism. While the Bank states explicitly that it excludes the political aspects of good governance as not being part of its mandate it sometimes seems to come quite close. "In its role as chairman of Consultative Group (CG) meetings between donor agencies and governments, the Bank has at times communicated to borrowing countries the views of donors on issues relevant to the political dimensions of governance that fall outside the Bank's mandate" (World Bank 1994: xvii). The good governance agenda seems to be concerned mainly with economic policy: "matching the state's role to its capability" and, at a later stage, to "raise state capability by reinvigorating public institutions" (World Bank 1997)[16]. But shrinking the state is a highly political issue. As Stoker (1998) observed, governance is often "the acceptable face of spending cuts."

Others have criticized the World Bank model of governance for the fact that it fails to recognize the fundamental political nature of governance and seems to be unconcerned with the form of government. Guhan (1997) argues that the Bank sees liberal democracy as being of instrumental value but not of "foundational or intrinsic importance", making it an unacceptable definition for those who believe that "an open, liberal democracy is the non-negotiable bedrock of what good governance must mean". He reviews six characteristics of the World Bank's concept of good governance. First, he sees the Bank's good governance concept as narrowly technocratic: it is not much more than an updating of the "night watchman state" through added concerns for the environment and vulnerable groups. Second, the Bank does not recognize the diversity of developing countries and issues standard prescriptions to very different countries, using a one size fits all model. Third, the Bank has a questionable track record: the evidence of the Bank's efficacy is far from conclusive. Fourth, the World Bank is an interested party and uses propaganda, persuasion and leverage through its publications and loans. Fifth, the Bank's concept ignores the "reform paradox" that only a

[16] Guhan (1997, 18) observes that this is like putting the cart before the horse, as it is particularly in the early stages of development that strong public institutions are essential, with the market being able to take a more prominent role at subsequent phases.

strong state can successfully oversee the transition from a state controlled to a market economy. Finally, the good governance concept ignores the issue of asymmetry in the dialogue: increasingly, the rules of the game are made by industrialized countries (e.g. in organizations such as WTO).

Sachs (1996) takes an equally critical view of good governance in developing countries, especially Africa. “In the 1980s ‘basic needs’ was supplanted by ‘structural adjustment’ which rightly focused on markets but neglected to set priorities for reform. In the ensuing frustration, the focus in the 1990s has shifted to ‘good governance’: donors now berate African governments for their ‘lack of ownership’ of reforms dictated by the IMF and World Bank.” Woods (2000) has argued that it is urgent for the IMF and the World Bank to apply their advice to client countries about transparency, stakeholder involvement and accountability to themselves as well.

The good governance debate has helped to put on the agenda issues of participation, corruption, democratic accountability, the need for transparent decision-making, and the importance of political pluralism. It has helped to turn the debate away from the management of sector policies and development projects to the governance system that provides the context and framework for policies, programs and projects. At the same time, the good governance idea, has often served the “neo-liberal” agenda of international agencies. The importance for agricultural innovation is that good governance in tandem with market liberalization and growing trade and FDI has dramatically changed the selection environment in which agricultural innovation takes place.

4.5 Corporate Governance: steering organizations towards performance

Corporate governance refers to the rules, institutional mechanisms, and structures used to direct and steer organizations. As such it deals with a wide variety of topics: ownership and control of the corporation, the mechanisms by which suppliers of finance ensure they get a return on their investment (Shleifer and Vishny 1997), and the relationship between stockholders and stakeholders (Freeman and Reed 1998).

Corporate governance involves structural units in organizations (boards), and instruments, incentives and processes (internal audits, performance incentives, funding mechanisms etc.). The understanding of corporate governance issues has been the subject of business administration and management studies, economics and institutional development research. The ideas of the NPM and of the NIE have had a strong influence on corporate governance. One particularly important issue is that, as a result of the prescriptions of the NPM, the concept of corporate governance is no longer limited to the private sector, but is now frequently used in (semi) public organizations as well (Kettl 2000).

Business administration has been a major contributor to the study of corporate governance. Corporate governance looks at the way organizations are structured, directed and supervised, in particular by governing boards or other oversight mechanisms. It deals in particular with the processes whereby corporate authority and responsibility are shared by owners, directors and management. The management literature (both popular and scientific) has always paid much attention to governance issues under different headings such as leadership, board evaluations and corporate culture. It has also helped to define what the appropriate roles and responsibilities are for leaders of organizations, and has helped benchmark “best practices” of different categories of business leaders. The business administration literature has helped to characterize the “governance” principles that underpin a successful corporate R&D effort. This literature has focused largely on private sector R&D efforts, but has relevance for public agricultural research as well.

The structuring and design of organizations has been the subject of many studies. Mintzberg (1979, 1983) is concerned with the design of effective organizations and, without using the concept of governance, addresses it in considerable detail. In a well known model Mintzberg distinguishes five organizational components: the operating core, the strategic apex, the middle management line (linking the operational core to the apex), the technostructure, and the support units. In the operating core people perform the basic activities that are directly related to the production of goods and services. The role of the strategic apex is to ensure that the organization achieves its mission, and that it supports those who control the organization including owners, managers, labor and other stakeholders (Mintzberg 1983). The strategic apex faces three sets of duties. The first is direct ***supervision***: the managers in the strategic apex allocate resources, authorize decisions, resolve conflicts and monitor employee performance. A second duty is the management of the organization’s ***boundary conditions***, or its relations with its environment. Top-management needs to lobby for the organization’s interests, attract resources and perform ceremonial duties. The third main task of the apex relates to the development of the organization’s ***strategy***. An important aspect of strategy is to translate the implications of challenges in the external environment for internal activities, and while all parts of the organization will be involved in strategy formulation, the apex needs to play a prime role. In Mintzberg’s view the strategic apex includes both the leadership of the organization (its Chief Executive Officer) and the Board of Directors or an equivalent non-executive supervising body. In this view governance is where the internal and external environment of an organization meet (Lusthaus et al. 1995).

Bilimoria and Piderit (1994) see three interrelated functions for governance: ***legitimizing*** (ensuring the fulfillment of legal requirements), ***directing*** (determining the overall mission, direction and broad strategies and policies of the organization), and ***overseeing management*** (maintaining the integrity of corporate assets by ensuring the continued competence of management). It is important to keep in mind the explicit distinction that this definition of governance makes between governance and management functions. As governance is potentially a very broad subject, its scope and limits need to be clearly defined. A narrow definition by Tricker (1994) limits corporate governance to “issues facing boards of directors”. A broader view on corporate governance would state that boards of directors are but one part of a ‘governance system’ that may include regulation by national and local governments, pressures from societal groups, and relations with a variety of suppliers and clients.

The literature on corporate governance can be divided into two broad categories, one more normative, focusing essentially on how to improve or strengthen corporate governance, the other more empirical and analytical in nature. The governance improvement literature is primarily aimed at practitioners and decision-makers. The more analytical literature contains analyses of how governance systems actually function, how they change, how board composition influences organizational performance, and how important the role of leadership is. Both types of studies focus particularly on the private sector in the USA and Europe and to a smaller extent in Japan.

There are two opposite views that determine the current debate on corporate governance: the shareholder perspective and the stakeholder perspective. The "shareholder revolution" is a movement to put pressure on companies to ensure maximum returns for the providers of capital. The movement is particularly strong in the USA an increasingly prominent in Europe as well. The stakeholder perspective is partly a reaction to the shareholder revolution, and partly an autonomous phenomenon, stronger in Europe than in the USA. The essence of the stakeholder position is that corporations need to take into consideration the legitimate interests, not only of the owners, but of important groups both inside and outside the organization. Originally the concept of stakeholder was defined in 1963 at the Stanford Research Institute as "those groups without whose support the organization would cease to exist" (Freeman and Reed 1998). Freeman and Reed propose to distinguish two categories of stakeholders. Stakeholders in the wide sense are those groups that can affect the performance or are affected by the performance of the organization. Stakeholders in the narrow sense are identifiable groups on which the organization is dependent for its survival. The former include public interest groups, trade associations, government agencies, competitors as well as the stakeholders in the narrow sense who include employees, customers and banks. Critics of the stakeholder view argue that business should dedicate itself to its core mission: the creation of wealth (Novak 1997).

The stakeholder view of the firm has made an important contribution to the concept of corporate social responsibility (CSR), which is closely linked to the Triple-P notion, and which suggests that firms should not just be concern with profit, but also with stakeholders and society (People), and the environment (Planet) (Van Tulder 2006). CSR has evolved from doing good to a business strategy that makes economic sense e.g. by appealing to environmentally conscious consumers or in developing products and services that cater to needs of poor consumers or (agricultural) producers (Prahalad 2005, Kolk and van Tulder 2006). This has implications for agricultural innovation as well: the involvement of small growers in agri-food chains governed by MNEs is potentially a powerful instrument for upgrading production practices. This often involves the introduction of new institutional arrangements such as contract farming, and the use of quality standards.

4.6 Network Governance

Networks have become a popular object of study since the beginning of the 1990s. The rise of the "network society" (Castells 1996, Gibbons 1994) reflects the increasing importance of democratic process, civil society and of horizontal modes of interaction. The concept of the "network economy" (Shapiro and Varian 1999) is modeled on the internet and describes a system that is strongly focused on innovation and that is suspicious of central steering by government as well as of the dominant influence of large corporations.

Much of the literature uncritically considers networks to be a good thing for participants and for society at large. Networks may help individual actors achieve objectives that would otherwise be out of their reach. Networks are important in an increasingly complex society where governments must involve partners in society to achieve objectives. But networks are by no means a panacea for interorganizational coordination. Many networks (cartels are an example) aim to limit participation and competition while other networks lock in dependent participants on unfavorable terms. It is important to distinguish normative, prescriptive approaches from descriptive and more analytical approaches.

This section starts with a discussion of two different rationales for the existence of networks that have been advanced by public administration, and by transaction cost theory respectively. This review provides a basis for a discussion of how network governance differs from other types of governance.

4.6.1 Interdependent actors in complex networks: a public administration perspective

The rational organization model (as presented in Weber's bureaucracy and Taylor's scientific management of organizations) sees organizations as coherent units with a clear purpose, and essentially without relations with their environment. Systems approaches (Mintzberg 1979) propose that organizations consist of subsystems (that need to be coordinated), and of an external environment to which the internal organization needs to adapt. The study of networks is based on inter-organization theory and it focuses on the relations between organizations and the control over and exchange of strategic resources between them as described in resource dependency theory (Pfeffer and Salancik 1978).

The public administration literature on networks presents increased societal complexity, the need for participation and political pluralism, as well as the role of civil-society in delivering services as key rationales for the formation of networks. The focus is on the development of new perspectives and instruments for governmental regulation, intervention and steering.

While the traditional public administration model provided a clear distinction between a steering governance body and a steered system, the newer public management approaches acknowledge that such a simple approach is unlikely to be able to address the complex problems of today's societies in an effective manner. The public administration idea of governance as the management of networks recognizes that networks are unique institutional arrangements, and that their governance requires a unique set of instruments[17].

In the public administration tradition the purpose of networks (often described as "self-organizing") is to design and implement policies and to deliver services in complex environments, requiring the involvement of a variety of actors: "Public policy is both made and implemented in networks of interdependent actors" (Kickert 1997: 2). These policy networks are seen as more or less "stable patterns of social relations between interdependent actors, which take shape around policy problems and/or policy programmes" (Kickert 1997).

[17] As such the prescriptions of the NPM that propose private sector solutions to public sector problems are rejected as simplistic.

The concept of interdependence is important in the public administration literature because in today's world, government alone cannot solve key societal problems and participation of public, private, and civil society organizations is necessary. In addition, each actor has unique resources to contribute. Government provides legitimacy and funding, local organizations provide knowledge on clients, universities provide research methods and insights, and the private sector may provide specific inputs and expertise. The main characteristics of policy design and implementation networks may be summarized as:

- Organizations are part of a network of organizations
- Emphasis is on inter-organizational action
- Interaction is guided by organizational arrangements (rules)
- Decision-making is based on negotiations between interdependent actors
- There is no central authority structure
- The values of the different actors may be conflicting.

Three comments can be made. First, while the public administration approach to networks broadens the perspective on policy design and implementation and emphasizes its dynamic and interactive nature, its focus continues to be on the role of the public sector, viewing the roles of other actors through the lens of public policy. Second, the implicit or explicit interdependence assumption appears to ignore issues of asymmetric relationships, power and dependence between actors in networks. Third, the public administration perspective emphasizes political decision making over economic interests and bargaining. The following section discusses these issues in more detail, and argues that interdependent policy networks are a special case.

4.6.2 A transaction cost perspective on networks

The transaction cost literature emphasizes that transactions in markets, hierarchies and hybrids (networks) are governed by different rules. Hybrid institutional arrangements are not a loose amalgam of hierarchy and market, but have their own discipline and rationale (Williamson 1995). Markets are "spontaneous" forms of governance where the price mechanism plays a central role. Hierarchies are "intentional" forms of governance where decisions are made by administrative fiat within organizations. Hybrids have their own mechanisms: they can be seen as "thin" markets, with specific contractual relations, long term, reciprocal relationships, collaboration and regulation.

Hierarchies and markets are "ideal type" opposites that represent different modes of governance. Williamson states that each generic mode of governance differs from others in three respects. First, each mode of governance is supported and defined by distinctive forms of contract law: in the case of markets contract law is explicit, whereas in hierarchies contracts are implicit. Second, they differ in adaptation mechanisms. Williamson sees adaptation as the central economic problem and argues that in markets autonomous adaptation takes place in a highly efficient manner in response to price signals (spontaneous governance). Adaptation within organizations takes place in a different way, through coordination (intentional governance). Third, different instruments are used in markets and in organizations to different degrees: whereas markets tend to rely more strongly on incentives, hierarchies rely to a larger extent on administrative controls (Williamson 1996: 104).

Williamson's contribution has been to highlight the importance of hybrid forms of governance, emphasizing how hybrids differ from markets and hierarchies. Hybrid organizational forms include network configurations, but can also constitute a single organization of the hybrid type. Because they are a class of their own, hybrids are governed by specific contract forms that are appropriate for "thin" markets with small numbers of players that enter into long-term relationships (using appropriate contractual forms such as franchising) and where reputation effects are important. This contrasts with "thick" markets where there are many parties, where competition is atomistic, transactions are "arms-length" and reputation effects are relatively unimportant.

Under hybrid forms of governance, market prices do not exclusively determine with whom to transact. Networks are non-hierarchical contracting relations, where there are few partners and where reputation effects are important in determining with who to transact. Williamson's view that hybrids are governed by their own rules constitutes an important critique of the ideas of the NPM which assumes that private sector practices can be readily transferred to the public sector. As organizational change in public sector monopolies (including agricultural research and development) is more likely to result in hybrid forms than in true market forms, it follows that specific governance mechanisms and instruments are needed. A competitive fund for agricultural research or innovation, for example, does not constitute a true market. It operates in an environment with a small number of suitable applicants that have known each other and their reputations for a long time, and that often have unique or complementary capabilities. Such situations require specific rules and mechanisms to ensure a balance between competition and collaboration.

In Williamson's view an important characteristic of hybrid forms (such as networks) is that they are much more susceptible to disturbances than either markets or hierarchies. This is because hybrid adaptations cannot be made unilaterally (as in markets) or by fiat (as in hierarchies). Rather, decision-making in networks requires consent, negotiation and bargaining to achieve consensus. This is particularly the case in those networks that integrate a variety of actors with different objectives and policy agendas. Other authors, however, have emphasized that networks, once established, can be highly resistant to change (Börzel 1997).

Two observations with regard to the transaction cost perspective are in order. First, authors such as Powell (1990) and Williamson (1996) replace the original set of two ideal types (market and hierarchy) with a set of three ideal types by adding networks as a distinct mode of governance. In practice, of course, a large variety of different types of networks exists, some closer to markets (institutions, incentives and spontaneous governance) and others closer to hierarchies (with the characteristics of organizations, intentional governance, and an emphasis on regulation).

The second observation with regard to the transaction cost perspective is that it stresses the importance of asymmetric information, rent seeking, free riding and self-serving, opportunistic behavior by agents (Hodge 1996). Principals delegate tasks to agents, who have more detailed knowledge of the specific task at hand. But as a result, principals are confronted with monitoring costs. This situation appears to be characteristic of networks controlled by one or a few dominant partners. As mentioned, other authors, particularly in the public administration tradition, tend to highlight the interdependence of actors in a network thereby assuming implicitly, or explicitly, that actors are essentially equal partners. Rather than discussing the problems of opportunistic behavior, these authors emphasize the key role of trust as the glue that holds networks together (Özgediz and Nambi 1999). The difference between asymmetry and opportunism in networks vs. interdependence and trust is analyzed in the political economy perspective on networks.

4.6.3 A political economy perspective on network governance

The building blocks of networks are actors and the relationships between actors. The nature of networks is determined by the type of the actors (organizations) and the nature of the interaction between the actors. Organizations are not only interested in the implementation of policy, or in minimizing transaction costs, but they frequently attempt to influence the decisions or actions of others and to change the rules of the game. Power and influence are important concepts in network analysis and concern the distribution of resources, authority and information.

In their analysis of industrial restructuring Ruigrok and van Tulder (1995) take a political economy perspective, emphasizing issues of power, control, dependency, and bargaining in industrial networks. These networks consist of heterogeneous actors (a core company, suppliers, distributors, banks, governments and trade unions) that have different objectives and that need to arrive at a consensus through bargaining processes. The outcome of these bargaining processes depends on the power and dependency relationships that exist between the different actors, and results in different types of networks or network constellations.

At the basic level, power and dependency relations in networks can be analyzed on a pair-wise basis, or as “dyadic” relationships between two actors. Table 4.1 presents three basic positions: two actors (organizations) can be independent, interdependent, or one can be dependent on the other. Intermediate positions are situations of independence with influence, and dependence with influence.

The specific position of an organization in relation to another organization will result in different bargaining attitudes. Two independent organizations in a network may either compete or cooperate, interdependent organizations will enter into a coalition and a dependent organization will be under the control of another organization. Control situations can be either structural, or direct, depending on whether there is a market, or hierarchical relationship. “Compliance” is a bargaining attitude that results when an organization is influenced to a considerable extent by a powerful other actor.

The analysis of Ruigrok and van Tulder provides an essential expansion of the transaction cost perspective: rather than capturing networks under the single category of “hybrids”, it presents a variety of different types of networks based on the nature of the relationships between actors. Power, dependence, and influence in network relations results in a variety of network types and corresponding differences in governance.

Table 4.1 Bargaining positions and network types

Position of supplier	Attitude of core company	Type of network
Independent	Cooperation or competition	Egalitarian learning
Independent with influence	Compliance	Chaos: searching
Interdependent	Coalition	Influence
Dependent with influence	Direct Control	Formal hierarchy
Dependent without influence	Structural control	Informal hierarchy

Source: based on Ruigrok and van Tulder 1995

In addition, this approach provides a basis for the analysis of different types of networks. It focuses on a defined set of actors in a network with a defined set of tasks. It uses dyadic (two-way) relationships between actors as the basis for analysis of relations in a network, the network being the sum of all dyadic relationships between actors. The issue of network analysis will be pursued further in the next chapter.

4.6.4 Network governance, institutions and agricultural innovation

The implications of the governance of networks for agricultural innovation can be summarized in three points. First, networks as an institution of governance are fundamentally different from markets and hierarchies. On the one hand networks are considered to be inherently unstable because they integrate actors with partly conflicting values and interests (Williamson 1996). On the other hand the possibility to involve a wide variety of different actors is the most important advantage of networks. Agri-food chains, for example, provide an important institutional framework for agricultural innovation and they involve actors which, at the same time, have parallel and conflicting interests. All parties in a chain benefit from producing high quality and safe products, but there is a continuous battle over how cost, benefits and value added are distributed between actors in the chain. Networks play an important role in conflict resolution and in intermediation.

Second, there are many different types of networks – some are more like markets, others resemble more strongly coordinated hierarchies. Some of the network literature discussed above assumes that networks are inherently beneficial to participants and that they form a panacea to the problems of interorganizational coordination. Egalitarian and interdependence networks are, however, special cases dominated by horizontal relations. Hierarchical networks dominated by vertical relations may “lock in” dependent partners on highly unfavorable terms.

Third, networks are seen as thin markets, where reputation effects are important in determining with whom to transact. Thin market characteristics include a small number of non-anonymous actors, reciprocity, and long-term relationships. All of these are important for agricultural research, development and innovation networks.

4.7 Conclusion

A broad consensus has emerged on the importance of institutions for economic development. As Fukyama expressed it: "I believe that the institutionalists have won this argument hands down (The Economist 2008: 84)." Nelson (2008: 1) concurs with this assessment of the role of institutions in economic growth, but adds that "… with few exceptions the exploration of the role of institutions has not been connected with a coherent analysis of the relationships between institutions and institutional change and technological advance." Nelson argues that technical and institutional change (or physical and social technologies as he calls them) need to go hand in hand, and that physical and social technologies co-evolve. The importance of institutions in the innovation process is that: "…institutional change, and its influence on economic activity, is much more difficult to direct and control than technological change, and hence prevailing institutions often are drags on economic productivity and progressiveness Nelson 2008: 2)." The following chapter addresses these questions in an analysis of how innovation is organized and how technologies and institutions co-evolve in the context of systems of innovation and innovation networks.

5. Actors, networks and systems: the organization of innovation

5.1 Introduction

Innovation is an interactive process which requires the involvement of different actors. These may be located in different units of a single organization, or in different organizations. While large enterprises may innovate within the boundaries of the organization, other situations, especially in the agricultural sector – where there are many producers, suppliers and a number of public and private R&D organizations – require the involvement of different organizational actors.

Innovation is a process that can be steered and planned only to a limited extent. Innovation involves bargaining processes between a variety of different actors, some of who have more knowledge, resources and political power than others. Technical change and innovation – in agriculture as well as in other sectors – often takes place in a situation of conflict over the nature of the technology, the use of scarce resources, and the distribution of benefits. In such inherently complex and often unstable situations, arrangements between organizations are needed to manage competition and cooperation and to mediate between the different interests of organizations involved in innovation processes, characterized by partially overlapping and partially conflicting objectives (Teece 1992).

This chapter builds on the discussion in previous chapters on technical and institutional change and focuses on the actors involved in agricultural innovation and on how innovation is organized between different (types of) actors.

Following a presentation of the key actors in agricultural innovation this chapter analyzes two different approaches to the organization of innovation: first, interorganizational partnerships and networks, and second, the co-evolution of technical and institutional change in innovation systems. The difference between the two approaches is one of degree and there are different shades of gray. Examples of network approaches that are relevant for innovation include R&D networks (Gassmann and von Zedtwitz 1999), techno-economic networks (Green et al. 1999), innovation networks, supply and agri-chain networks (Maijers 2000, Gereffi 2001). The "soft systems" literature, for example (Clegg and Walsh 1998) takes an intermediary position between systems and network approaches. National systems of innovation (NSI), regional and sectoral innovation systems and Agricultural Knowledge and Information Systems (AKIS) are exponents of the systems literature.

5.2 Agricultural innovation actors

Schumpeter in his early work emphasized the role of the individual entrepreneur as an innovator. In his later work he drew attention to the role of organizations in the innovation process. More recently, Leydesdorff (2000) has elaborated the importance of the interaction between actors in the triple helix of university-industry-government as a fundamental aspect of the innovation process.

In agricultural innovation individuals and organizations (both public and private) are important. For centuries individual farmers experimenting with new seeds and cultivation practices have advanced the state of knowledge. Since the 19^{th} Century organizational actors, such agrochemicals companies, universities, and state experiment stations have become responsible for most of the major breakthroughs that have lifted agricultural productivity to unprecedented levels. The most important actors in the agricultural innovation are: research organizations, universities, input providers, technology users, intermediary organizations, pressure groups, financiers and regulators. Some are public organizations, others private. Some types of organizations, such as seed companies, can be private or public – although there is a strong tendency in most developing countries for state-owned enterprises in agriculture to be privatized.

Agricultural ***research organizations*** produce new knowledge and technology. Traditionally, in the 'linear' view of innovation, agricultural research organizations have been seen as the 'core institution' generating and transferring new technology to a variety of users who were seen as passive recipients. Newer approaches to innovation and the production of knowledge emphasize that innovation is a multi-faceted, interactive process, and that new insights and innovations may originate in many different places in the network.

Public sector agricultural research organizations are seldom the sole source of formal research. With the exception of the smallest and poorest countries, agricultural research is conducted in number of other research organizations, in universities, in private sector labs, in seed companies and voluntary organizations. Competition in the provision of knowledge in the field of agriculture has increased as in many developing countries there is dissatisfaction with the performance of the traditional public sector research organization. National and international research financiers increasingly channel funding through universities, NGOs and foundations, sometimes directly, sometimes as a result of the introduction of competitive funding mechanisms. The role of universities in agricultural research and innovation is strongly country specific, depending on the historical evolution of the university as a teaching and or a research institute.

In many agricultural innovation networks public sector agricultural research organizations can be considered a key player – although the absence of effective network relations with other actors in the network explains to a large extent why public sector agricultural research has sometimes failed to deliver the goods, delivered the wrong goods or delivered them to the wrong people. The private sector is becoming increasingly involved in research, but is focusing in particular on larger markets, appropriable returns (intellectual property regimes), and on countries that have a good scientific infrastructure and favorable policies (Pray and Umali-Deininger 1998, Fuglie and Pray 2002).

Often in agriculture, innovative technology does not come (directly) from research organizations but from ***input providers***. Much agricultural technology is embodied in seed, chemicals and other inputs – as well as in machinery and designs used by farmers and processors (Roseboom 1999). With the exception of planting material, where public sector seed companies continue to play an important role in many countries, inputs are increasingly provided through private sector companies. Many parastatals have been disbanded or privatized since the beginning of the 1990s, making the private sector an increasingly important player in innovation networks. As intellectual property regimes are strengthened as a result of WTO regulations, developing country markets become increasingly interesting for multinational agribusiness companies.

Food processors, food producers and distributors are playing an increasingly important role in the agricultural innovation process. Most of these are private companies as the public sector in most countries has withdrawn from direct involvement in the primary agricultural production process. Food processors (including slaughterhouses, milling and canning industries) are becoming increasingly important as they often add considerable value to primary crop production. Food producers such Unilever and Nestlé are becoming large providers of FDI. Internationally expanding retailers like Carrefour, Metro and Ahold are key players in organizing the global agricultural value chain and in the process they have become key players in agricultural innovation.

Technology users are mostly farmers, but include processors as well. Criticism has been voiced against agricultural research organizations for being insufficiently relevant and responsive to the needs of farmers and other users (Chambers et al. 1989). When technology users are also the funders of research, as, for example in some plantation crop research institutes, a user orientation comes more naturally, particularly as the number of users is small and well informed. In food crops research that focuses on the needs of millions of smallholders in a variety of ecological and production systems such a user orientation is much more difficult to achieve. Much progress has however been made since the 1980s as a result of farming systems and participatory research approaches. With the increasing importance of environmental concerns in agricultural research and donor demands to address poverty through research the issue of identification of users and targeting research has become again more complicated.

Intermediaries are those organizations that play a role in the dissemination and/or adaptation of research results to specific groups of technology users. They include governmental extension organizations, rural development programs and non-governmental organizations. The rise of the NGO sector can be explained partly by the disappointing performance of government extension services. The issue of research-extension linkages has received considerable attention in the literature (Anderson and Feder 2003) and is important in studying innovation networks.

Pressure groups attempt to influence the research agenda for a number of reasons: the nature of the technology, the use of resources in agricultural production, and the quality of the product. The nature of agricultural technology has been a source of conflict throughout history and has been discussed elsewhere in this study. Resources for use in agricultural production (land, water, germplasm) become increasingly scarce and contested with population growth and environmental degradation; and as a result their protection from general use becomes more dominant. Product quality is usually a main concern of consumer organizations in developed countries, though consumer voices are weak in developing countries. While consumer preferences are a primary concern in private sector research efforts, public sector agricultural research has struggled to generate technologies acceptable and profitable to farmers, and has often totally neglected the more complicated question of how to include consumer preferences in research. Taste, cooking qualities, shelf life and chemical residues are issues of primary concern. A strong lobby has been developed by international NGOs (such as Greenpeace, Grain and ETC/RAFI) to ban production and trade of genetically modified crops. But the area under GMO crops continues to expand rapidly in many developing countries and the life sciences companies (led by Monsanto) are increasingly successful in development and transfer of GM technology packages (Business Week 2008).

Financiers of research and innovation are important actors. Food security in most developing countries continues to be seen as a primary government responsibility. As a result, agricultural research has traditionally been funded primarily by national governments. International donors also provide large sums of money to national and international agricultural research focused on developing countries. Two major changes taking place are decreasing funding levels in many countries, and the introduction of different funding mechanisms. Philanthropic organizations have played a major role in financing agricultural research – this includes the Ford and Rockfeller Foundations, which were instrumental in starting the green revolution, while the Bill and Melinda Gates Foundation has emerged as an important funder since the year 2000.

Besides playing an important role as financier, government is also is the most important ***policy maker and regulator*** of research undertaken and technologies developed. Indirectly, governments steer research and innovation activities through prices, subsidies and taxes. Directly, governments play an important role through the provision of quarantine services, seed certification, rules on the use of agro-chemicals, land-use and zoning legislation, intellectual property, technology policies, food safety, the use of genetic resources, biosafety, etc. Different levels of government usually are involved in regulating research, either directly or through the agricultural production process. National government is however not the only regulator: in the management of common pool resources, local government and communities often play a primary role. Increasingly, regulatory decisions are taken at supra-national levels in bodies such as WIPO, and WTO and the EU (see Chapter 2). But perhaps the most important change since the mid 1990s is the emergence of private standards to assure food quality and safety (Busch and Bain 2004). The quality assurance schemes imposed by private organizations are often more demanding than the public sector standards, which are often not enforced in developing countries.

5.3 Innovation partnerships and networks

Globalization and the information technology revolution have contributed in a major way to the formation of the “network society” (Castells 1996). Research, development and innovation are becoming more and more network-based. The network model of open innovation is replacing the closed model of innovation, which was dominant during the “golden age of corporate R&D” – roughly the period 1950 to 1980 (Auerswald and Branscomb 2005). Since the 1980s corporate R&D has become more closely integrated in companies’ business units. Outsourcing of production which took off at the same time was followed by the external sourcing of R&D services. Public agricultural research has been an international activity since the 1940s when Ford and Rockefeller Foundations started to support applied research into new high-yielding plant varieties. This section analyzes the key rationales of innovation partnerships, alliances and networks, analyzes structural aspects of networks and presents a typology of networks.

5.3.1 Rationales and functions of networks

In general, networks are relevant for innovation for a number of reasons:

- Innovation networks allow the inclusion of a variety of dependent, independent or interdependent actors (Ruigrok and van Tulder 1995). Innovation networks can be seen as institutions that resolve conflicts between actors.
- Innovation networks involve both patterns of horizontal cooperation and competition as well as vertical integration. (Beije 1998). Vertical integration is the process of establishing forward and backward linkages throughout the production column or value chain.
- Innovation networks include both organizations and institutions: they specify both the actors (organizations) and the rules or mechanisms (institutions) that determine interaction.
- Innovation networks include both technical and institutional innovation.

Networks serve a dual purpose in innovation processes: they create the necessary relationships and arrangements between actors, and they provide the institutional rules which govern the interaction needed for the innovation process. Organizations do not only participate in networks and partnerships to "play the game"; they are also interested in influencing the rules of the game. This is the case particularly in networks that are dominated by a single core actor who has effective control over other organizations in the network (Ruigrok and van Tulder 1995).

Traditionally, the literature dealing with public and non-profit sector roles in innovation has highlighted the importance of cooperation to achieve public goods that are beyond the capacity of individual organizations to achieve. The public administration perspective, discussed in the previous chapter assumes a common purpose and interdependence between actors. The private sector innovation literature, on the other hand, focuses on the role of the firm, and has tended to emphasize the importance of competition in innovation.

Teece (1992) discusses different types of governance and organizational arrangements in situations of rapid technological change in an article entitled "Competition, cooperation and innovation". While the importance of competition for innovation has been recognized starting with the early writings of Schumpeter, it provides only a partial explanation for innovation. Teece argues that innovation is a highly complex process that requires elaborate forms of horizontal and vertical cooperation. Cooperation achieves both operational and strategic coordination. Operational coordination is needed for four main reasons:

1. To access complementary assets. Developing a technology is only a first step in the innovation process. A range of complementary activities needs to be accessed. In agriculture these include for example marketing, the services of extension agencies, need to have access to materials in gene banks, etc.
2. To link developers of new technology to users and suppliers. Tight "upstream" and "downstream" linkage and feedback mechanisms with suppliers of new technology

and with users are key to the success of the innovation process. Teece, like von Hippel (1994), stresses the role of users in technological innovation.

3. To provide linkages to competitors. Horizontal linkages are important to establish technical standards that are key requirements for innovation. Similarly, both in private and public research, the scale and scope of assets needed lies beyond the capabilities of a single firm or organization. In such situations cooperation (with colleagues or competitors) is the only way forward.
4. To build connections among technologies. Innovations are not developed in a vacuum. They build on prior technologies and designs, they require complementary technologies (e.g. zero tillage management requires the use of herbicides), and they may be linked to generic, enabling technologies (e.g. biotechnology).

Having highlighted the importance of coordination, Teece (1992), following Williamson (1985) discusses the three key governance structures that facilitate innovation. The first is coordination by the market through the price mechanism. Teece argues that there is no evidence that the price mechanism allows all of the necessary coordination to take place. The alternative – internal coordination in hierarchies – also has serious drawbacks. In most cases strategic alliances and inter-firm agreements and partnership are essential to achieve innovation effectively.

The second rationale for networks is that they also provide a means to define the conditions under which the innovation process is undertaken and the rules that apply (the governance function). This network rationale is particularly important when public and private sector participation in innovation is required. Both governments and private enterprises have engaged in the establishment and operation of innovation networks and partnerships. Governments have promoted and supported research partnerships in order to:

- Correct market failures in R&D investment, particularly in the presence of highly non-appropriable research, and lack of effective demand;
- Speed up technological innovation, aiming at increased international competitiveness;
- Increase technological information exchange among firms, universities, and public research institutes.

Private sector firms may participate in research partnerships for innovation for a number of different reasons as presented by Hagedoorn (2000), on the basis of a review of theoretical and empirical literature:

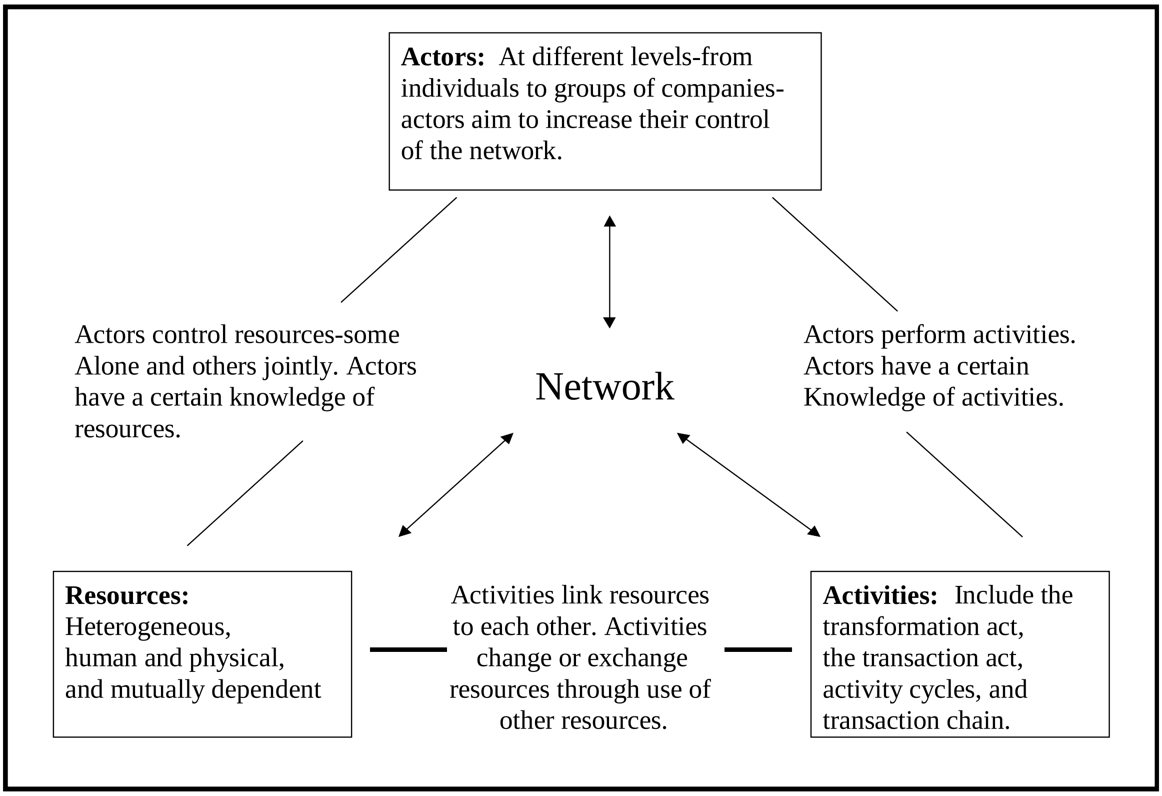
- Decrease transaction costs in activities governed by incomplete contracts;
- Broaden the effective scope of activities
- Increase efficiency, synergy, and power through the creation of networks;
- Access external complementary resources and capabilities to better exploit existing resources and develop sustained competitive advantage;
- Promote organizational learning, internalize core competencies, and enhance competitiveness;

- Create new investment options in high-opportunity, high-risk activities;
- Internalize knowledge spillovers and enhance the appropriability of research results;
- Lower R&D costs, and pool risk;
- Co-opt competition.

5.3.2 Structuring networks

In Håkansson's network model (Fig. 5.1) resources, actors and activities form the key elements of networks. This section discusses network resources and the relationships between actors. The following sections present network types and activities.

Figure 5.1 Håkansson's network model



Source: Beije (1998)

Network resources

The effectiveness of external linkages and therefore of networks, depends on the in-house resources and capabilities, not only for selecting among suppliers and technologies, but also for exploiting external collaborations for the purpose of implementing organizational strategy (Wang and von Tunzelmann 2000).

Resources can be tangible or intangible. Tangible resources comprise financial, physical and human resources. Intangible resources of networks according to Kash and Rycoft (2000) include existing core capabilities, existing complementary assets, and the ability to learn. Core capabilities include the knowledge and skills that give the network the ability to innovate. Core capabilities may be broad (e.g. system integration) or narrow (e.g. the capability to conduct research). Complementary assets are important to appropriate the benefits of new technologies. They are supplementary capabilities that need to be utilized to take full advantage of core capabilities. For a research organization, for example, the capability to package knowledge and technology for dissemination to clients and users is an important complementary asset. For innovation networks the ability to learn (and to continue to learn) is essential to replenish the stock of knowledge and skills, both at the level of the actors and at the level of the network. Learning capacity becomes increasingly important when networks become more complex.

Organizations are endowed with a certain stock of resources, but they are also "resource dependent" on other organizations. Organizations, therefore engage in networks to gain access to, or control over resources that they do not possess themselves. While organizations have traditionally been seen as users of scarce resources, the notion that organizations are not only consumers of resources, but also as creators of assets has gained ground (Dunning 1998). This adds an additional rationale for engaging in network activity, namely the creation of assets, which, in many situations, can only be achieved by expanding beyond the boundaries of the organization. Depending on the type of network, new resources may be acquired in a variety of ways, including association, merger, coordination and investment (domestic or foreign).

Network relationships

A key aspect of network analysis concerns relationships and linkages between the actors in a network. In interorganizational networks legal or ownership relations and funding relationships are important, as are the flows of information and other resources.

The remainder of this section focuses first on the internal dynamics of networks, in particular the power and dependency relations between the actors in networks. Next, external dynamics, of networks are discussed, in particular the interactions of networks with their environment and the openness or closedness of networks. The section ends with a brief discussion of how network dynamics may change over time.

Internal network dynamics

The internal dynamics of networks depend in particular on the nature of the relationships between actors. Linkages between actors may range from simple and unstructured to highly structured and differentiated. As networks develop into more complex institutional arrangements the relations between the actors will become more differentiated than in simple networks. Some actors will (attempt to) assume a core position in the network that gives them centrality and prestige and they will use their position to steer networks in ways that are beneficial to themselves.

Ruigrok and van Tulder (1995) present three ideal types of networks, based on the dominant relationships between the actors. Basically, the pattern of relationships may be classified as based on independence of actors, interdependence between actors, or dependence of some actors on others[18]. The different positions correspond to different bargaining positions in networks: independent organizations may either compete or cooperate; interdependent organizations will enter into a coalition; and dependent organizations will be under the control of another organization. Based on the nature of the dominant relationships in a network, three ideal types of networks may be distinguished (table 5.1):

- Egalitarian networks, where most actors have a more or less equal say in the operation of the network.
- Coordination networks of independent partners, where joint planning of activities takes place, but implementation is the responsibility of the individual actors.
- Centrally steered networks that are driven by one or a few organizations, which have structural or direct control over other organizations in the network.

Table 5.1 Network interactions and network types

Dominant interaction	Bargaining attitude	Type of network
Independence	Cooperation or Competition	Egalitarian
Interdependence	Coalition	Coordination
Dependence	Control	Hierarchy

Source: based on Ruigrok and van Tulder 1995

In **egalitarian networks** the joint planning of activities is the basic feature of the network. But both the planning and implementation remain the responsibility of the independent and autonomous actors. They may negotiate and adjust their plans to fit with the objectives and activities of other partners in the network, but the final decision on actions to be taken remains with the individual organization. In egalitarian networks there are no joint control mechanisms.

In **coordination networks** the joint planning function is strengthened and there will be joint implementation of activities in a coordinated fashion. Usually, one or a few actors in the network will assume the role of coordinators or core organizations and relations within the networks become more differentiated. Coordination roles are often played by the key financial or technical players in a network; i.e. those with direct control of the funds or the technology. There are no joint authority structures or structural control mechanisms in place to steer participating organizations in a specific direction.

[18] The authors also present two intermediate positions: dependent with influence and independent with influence.

In **hierarchical networks** some actors are under the “structural control” (Ruigrok and van Tulder 1995) of others as they form part of an administrative hierarchy and in a sense are “owned” by a higher-level organization in the hierarchy. In addition to structural relationships of authority, some actors will depend on others for funding and other resources, a situation referred to by Ruigrok and van Tulder as “direct control”. In the private sector direct or market control often derives from oligopolistic relationships. In the public sector it is the control over funding and other resources that that determines the nature of relationships. Funding is essential if the network is to achieve more than an exchange of information. One of the reasons why formal networks in international agricultural research have been popular with donors is that they see it as an effective way to influence the agenda of large number of organizations with limited funding. The main characteristics of the three different networks discussed in this section are summarized in Table 5.2.

Table 5.2 Characteristics of different network types

Mechanism / type	Egalitarian	Coordination	Hierarchy network
Planning	Bottom-up	Joint	Top-down
Implementation	Independent	Coordinated	Integrated
Control	Absent	Indirect or direct	Direct or structural

External dynamics of networks

The boundaries of networks define what is inside and outside the network. Since networks are inter-organizational arrangements or soft systems, these borders are never absolute. In the literature both openness and closedness of networks has been emphasized as a characteristic of different types of networks. The closed nature of networks and their use as a mechanism to “lock out” actors has been analyzed in political science and in economics. Cartels are an example of closed networks that have been set up purposely to lock out newcomers. Openness of networks, on the other hand, has also been a main current in the literature and includes the idea that organizations increasingly need to tap knowledge and resources from other organizations to achieve their objectives (Gibbons et al. 1994, Chesbrough 2003).

In general, the openness or closedness of networks appears to be determined by four overall factors: network purpose and objectives, network integration, network size (number of actors) and network evolution over time.

The question about network objectives can be answered in a variety of ways. Possible network strategic objectives mentioned in the business literature (Preece 1995) include:

- Learning - the acquisition of know-how;
- Leaning - have a partner replace an activity previously performed y the partner;
- Leveraging - integration with partners to benefit from economies of scale or scope;
- Linking - vertical strategic alliances with suppliers, or customers);
- Leaping - into new areas of endeavor, benefiting from partner’s knowledge;
- Locking out - to reduce competition; cooperate rather than compete.

The most open networks are those mainly based on learning and leaning and leaping; they would bring in new partners into the network. Mature network would focus on leveraging and linking with a relatively stable set of partners. In the case of networks where "locking out" is the most important objective, the specific purpose of the network is to share benefits amongst a small group of participants, while passing the costs to those outside the network.

Network size and integration provide another explanation for openness or closedness of a network. This is related to the fact that there is a limit to the number of linkages that an organization can effectively maintain. A large network, by definition has a large internal environment, which would normally limit the options for external interactions. But also when a network is small, it may be more or less tightly integrated. The tighter the integration of a network, the more limited the scope for, and the benefits to relationships outside the network. When networks are loosely structured associations where information is exchanged on a voluntary basis and few essential activities are carried out by the network there is ample scope and opportunity for interaction outside the network. But if there is a strong steering of the network by one or a few core organizations, the integration will increase and the network will show a tendency to be more closed. This is a situation which may lead to the ***overembeddedness*** of actors in networks (Uzzi 1997).

Network dynamics over time

Openness and closedness can also be discussed from an evolutionary perspective, using a transaction costs rationale. Networks are 'hybrids' (between markets and hierarchies) and an important rationale for networks is to minimize transaction costs between participating organizations. When a network is started, organizations engage in alliances with other organizations as the benefits of entering into alliances exceed the costs. Once they become established however, networks may make it more difficult for new participants to enter. The costs of adding more participants will exceed the benefits. Even if there are no intentional barriers to entry, network growth and complexity will cause a network to become more closed. Stable, mature networks will have found a balance between the benefits resulting from increased interaction with relevant partners, and the governance and transaction costs of maintaining these relationships.

As the number and variety of actors increases, decisions will need to be taken about network participation, network openness and network boundaries. These decisions may be taken at the level of the network, if there is a central steering mechanism. The decisions may also be taken by individual actors, who find that the cost of participation exceeds the benefits. They would then have to decide whether to use their "voice" option to remedy the situation, or use their "exit" option (Ruigrok and van Tulder 1995).

5.3.3 Network types

Powell and Grodal (2005) present a typology of networks based on two dimensions: the type of linkages and the extent of embeddedness. Linkages differ in the purposiveness, ranging from informal to contractual. The embeddedness dimension ranges from fluid, open, short-lived linkages to stable and dense connections. This yields a typology of four network types as illustrated in table 5.3: community of practice, organizational network, supply chain, and strategic network. The configurations or topologies of the four network types are presented in figure 5.2.

The **community of practice** (referred to as the "invisible college" by Powell and Grodal 2005) is of an informal nature and based on voluntary relationships, established to explore areas of common interest or experience. Communities of practice type of networks are often temporary and may evolve into other types of networks, notably the **organizational network** (referred to as the "primordial" network by Powell and Grodal). Organizational networks involve mostly similar (rather than dissimilar) actors. These are often established networks that structure subsequent action and behavior. Organizational networks are usually highly organized with identifiable membership and close and dense ties. Sometimes they evolve into organizations and there are situations in which organizational networks have outlived their original usefulness, but continue to exist on the basis of past performance. Examples are professional and research networks, business associations, and industrial districts.

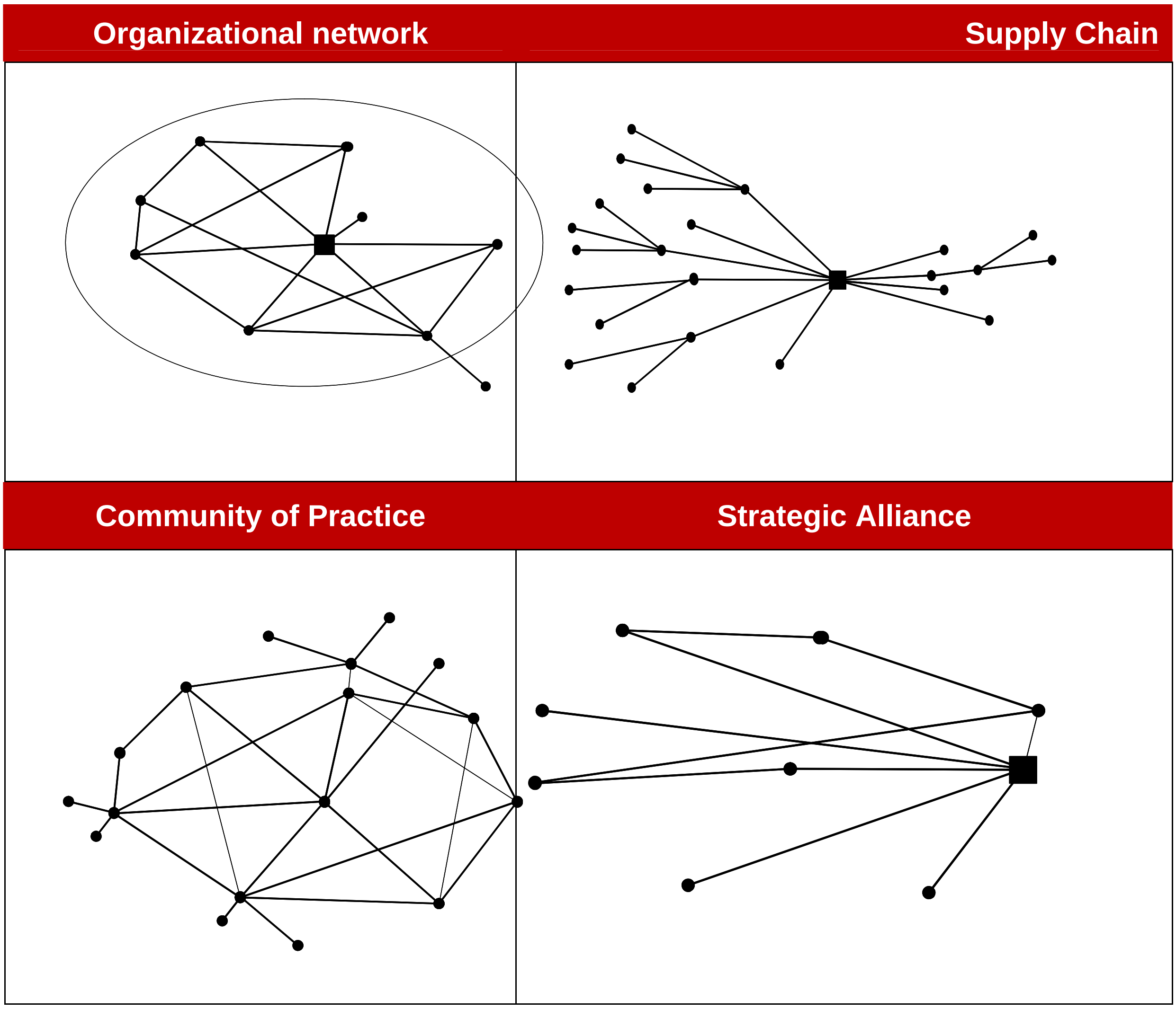
Table 5.3 Network typology

	Informal	Contractual
Closed networks	**Organizational network** • Similar nodes • Common social identity • Dense structure • Network exists prior to activity • Network forms basis for new activities	**Supply chain** • Dissimilar nodes • Common task / work identity • Horizontal or vertical specialization • Division of labor • Spider web • Controlled by dominant actor
Open networks	**Community of practice** • Similar and dissimilar nodes • Common interest • Fast access to new ideas • Ties reinforce the structure of the network	**Strategic alliance** • Similar and dissimilar nodes • Division of labor, recombination • Purposive network through tie creation • High tech industries (semiconductors, biotech)

Source: Adapted from Powell and Grodal (2005)

The **supply chain network** is structured around a common task, project or line of business. Supply chain networks are often structured by a lead firm operating as the core actor in the network. The **strategic alliance network** is open (like the community of practice), but relationships are highly formalized and of a contractual nature. These networks are often found in emerging high-tech areas of innovation such as biotechnology.

Figure 5.2 Network configurations



Sources: based on Powell and Grodal 2005), Lambert and Cooper (2000)

The different networks are not watertight compartments. Over time networks may evolve from one type to another in a variety of ways. Informal community of practice networks may become more highly structured with more closed membership around a certain discipline or line of business. They may also develop into a strategic network: many open research networks in the field of biotechnology have moved in this direction once it became clear that appropriating the benefits of knowledge required investment in complementary assets and protection of intellectual property. The following paragraphs illustrate the different network types.

Communities of practice: researcher and learning networks

Many research networks are networks of individual researchers. Their main purpose is advancing the state-of-the-art of knowledge through information exchange and learning. Many of these networks are global in nature and are truly invisible colleges.

Networks can go beyond the collaboration that is required to conduct specific transactions (i.e. supply networks), or beyond the collaboration that aims to develop new products or processes (innovation networks). Learning networks involve actors with the main purpose of knowledge generation or sharing, unrelated to specific innovative processes or products. Often they are not directly associated with any particular commercial transaction. Learning networks can sometimes be seen as the formative, “sensing” stage of innovation networks. They are often more open than innovation or supply networks as there are not yet commercial interests at stake. Learning networks are often found outside or at the periphery of the value chain or organizational network. Learning networks also have a stronger tendency to be networks of individuals (from organizations), rather than networks of organizations. Learning networks involve inter-organizational learning, focused on issues or objectives beyond the reach of the individual organization.

Learning becomes increasingly important in many organizations, including large multinational companies that have operations spread around the globe, and which operate as networks. Niosi (1999) finds that in large network-type of organizations a shift can be noticed from a model based on transfer of technology (from core to peripheral units based on the product life-cycle model) to a model that emphasizes that learning is a key element in the development of the new internationalization of R&D.

Organizational networks: Corporate R&D

The R&D network literature comes in two main parts. One group of studies reviews the interactions between universities, private or public research laboratories, and government. Recent models refer to a “triple helix” of university-industry-government relations (Leydesdorff 2000). The multi-institutional triple helix is inherently unstable and subject to disturbance by both internal and external dynamics. The approach allows for complex systems involving different actors and functions to be modeled.

Other studies on R&D networks emphasize the spatial organization of R&D activity within firms and between organizations. Within MNEs, which are the main international R&D performers, there is a continuous interplay of forces for centralization and decentralization of R&D activities. Centralizing tendencies can be explained by the high cost of R&D, scarcity of qualified manpower, and the desire to reap the benefits of economies of scale. Decentralization may be explained by the need to be close to diverse markets, and the need to benefit from the knowledge base in host countries (Albert 1999). Decentralization tendencies were strong in the 1980s, but the 1990s have witnessed a recentralization of R&D activities as a result of:

- Tighter integration of R&D in the organizational and competitive strategy of many MNEs;

- Increasingly costly R&D in life sciences and IT;
- Trends towards common standards and expected economies of scale.

Since the beginning of the 21st century a renewed decentralization process can be observed as MNEs attempt to source the best global technology irrespective of where or by whom it is produced. This process is accelerated by the IT revolution and the emergence of a number of developing countries (e.g. China, India, Brazil) as important R&D producers.

Gassman and von Zedtwitz (1999) present an integrated R&D model which balances decentralization and centralization tendencies in organizational R&D networks. The potential benefits of such an approach are obvious: global reach and local specialization can be achieved in the same system. The costs, however, may also be significant in terms of coordination and complexity in decision-making processes.

Supply and agri-chain networks

Supply networks and agri-chain networks are vertically integrated networks that link upstream and downstream activities in a production-marketing-consumption column. The concept has become prominent since the late 1990s and builds on the fields of value chain analysis, supply chain management, logistics and lean production (Gereffi et al. 2001, Ruben et al. 2006). Gereffi (2001) has drawn attention to the shift from producer-driven to buyer-driven value chains and further to integrated global value chains. Internationalization causes the geographical defragmentation of the physical supply chain and IT integration through transport and logistics systems (e.g. tracking and tracing).

Vertically integrated network exist in many different forms. Robertson and Langlois (1995) reviewed the industrial policy debate between proponents of large vertically integrated firms on the one hand and those of networks of small, specialized producers on the other. They argue that neither alternative is a panacea and that the menu of institutional choices is actually quite large. “Vertically integrated firms and loose webs of small producers are only two types of networks operating in today’s modern economies” (Robertson and Langlois (1995: 547). A variety of different types of integrated firms and networks can promote growth depending on the specific characteristics of a sector, county and technology.

Supply and agri-chain networks are important in agricultural innovation for a number of reasons: they bring embodied technology to the farmer, they introduce efficiency by linking farmers to traders, processors and exporters, and they introduce improved production standards, thereby providing an opportunity for “upgrading” production practices. Upgrading as an innovation strategy may involve product upgrading, process upgrading, functional upgrading (moving to a different position in the value chain with higher value added), or chain upgrading – i.e. moving to a different value chain (Kaplinsky and Morris 2002).
Agro-industrial chains often involve private as well public actors (Tripp and Pal 2000). The purpose of such public-private partnerships is to promote “co-innovation” activities (Maijers 2000).

Innovation networks as strategic alliances
Innovation networks involve collaboration between organizations with the objective of developing new products or processes. Three stages can be distinguished in the evolution of innovation networks. The first is referred to as sensing, or the development of new ideas. The second may be referred to as the response stage: it entails the actual development of products and processes. The third stage is implementation, or the exploitation, production and distribution of new products. The distinction between stages is important as innovation networks tend to evolve over time, from flexible learning and search networks to networks that supply and distribute goods and services or to organizational networks when technologies are mature.

5.3.4 Network complexity

Networks as a specific form of governance can accomplish a number of things that hierarchies and markets are not well equipped to do. This involves operating as thin markets where reputation effects are important, increasing the scope of activities beyond what individual would be capable of doing, integrate and balance the interests of actors with different objectives and other tasks discussed earlier in this chapter. But networks have their own limitations. A key issue in this respect relates to network complexity.

Network complexity is an issue discussed by a number of authors (Killing 1988, Hobday 2000, Kash and Rycoft 2000, Kickert 1997, Frenken 1999). Killing, for example, argues that the complexity of an alliance or network is a function of task complexity and organizational complexity. He finds that alliances that undertake complex tasks do not necessarily need to be organizationally complex; on the contrary, especially when tasks are complex, organizations should be simple enough to be manageable. Network complexity relates to a number of different network dimensions: actors, relationships, scope and content, and resources. All of these can contribute to network complexity as summarized in Table 5.4.

Table 5.4 Network dimensions and complexity

Dimensions	Issues	Categories
Network actors	Number of actors	Small/large
	Types of actors	Homogenous / heterogeneous
Network relationships	Internal dynamics	Egalitarian, coordination, control
	External dynamics	Open/closed
	Dynamics over time	Establishment/mature networks
Network scope and content	Vertical integration	Few/many steps
	Horizontal differentiation	Few/many activities
Network resources	Resource types	Tangible / intangible
		Core capabilities /complementary
	Resource use	Resource endowment vs. created assets
	Control over resources	Possession /access (sources)
	Resource rules	

Networks become more complex when the number of actors increases and especially when there are many different types of actors. Internal and external dynamics may be relatively simple or highly complex. Egalitarian networks, consisting of relatively homogeneous actors would be less complex than networks based on sophisticated mechanisms of control. Networks may also be relatively simple or complex with regard to vertical integration and horizontal diversification. With regards to the use of and control over resources, complexity increases if there are many different sources and types of resources and when the rules that guide resource use are contested.

5.4 Innovation systems

5.4.1 The co-evolution of technology, institutions and organizations

Many authors (Kash and Rycoft 2000, Radosevic 1998, Nelson 2008) have seen the integration (or co-evolution) of technical and institutional innovation as a key issue in innovation processes. Put simply, new technologies often require new rules (institutions) and organizational arrangements. “The self-organizing networks capable of innovating complex technologies are distinguished by the fact that they coevolve with their technologies. Coevolving networks and technologies are appropriately seen as sociotechnical systems, in which the networks and the technologies continuously shape each other” (Kash and Rycoft 2000: 820). Nelson (2008) refers to physical and social technologies when discussing the relationships between technical and institutional change. Others (Perez 2002) refer to “techno-economic regimes” or techno-economic paradigms when discussing the coevolution of technologies, institutions and organizations.

The relationship between institutions and organizations has been discussed in Chapter 4, and the argument here concentrates on the links between technical change vs. organizational and institutional change. The interaction between technical, institutional and organizational change is a complex issue. Sometimes, fundamentally new technologies (e.g. biotechnology and the Internet) force the rules of the game to be rewritten. In other cases institutional change (regulation, deregulation, or legislation) is needed to create the “enabling environment” for new technology to succeed and have an impact (e.g. the protection of intellectual property as a means to stimulate R&D in agricultural and medical biotechnology, or the imposition of technical standards such as GSM for mobile telecoms). Thus, institutions may be obstacles to innovation, or they may facilitate the innovation process. Institutions play a number of roles in innovation processes. They provide information (which reduces uncertainty), they manage conflicts and cooperation, and they provide incentives and resources to innovation activities. Similarly, organizations carry out searches for new knowledge, they change search strategies when needed, they utilize search results and new knowledge, they absorb knowledge created elsewhere, and they generate or promote the emergence of new knowledge (Edquist and Johnson 1997: 55).

The integration of technical and institutional change has been analyzed in the Technology-Economy study of the OECD (1992) – which builds on the evolutionary economics literature (Freeman and Perez 1988) – and which attempts to understand, at the macro level, the interaction between technical and economic change. Technological progress takes place within a technological paradigm, a concept analogous to Kuhn’s scientific paradigm: a model, or a pattern of a solution of selected technological problems, based on selected principles. A technological trajectory is the pattern of normal problem solving activity within a technological paradigm. A technological paradigm embodies strong prescriptions of the directions of technical change to pursue; these have a powerful exclusion effect in the sense that they are “blind” with respect to other technological possibilities, a phenomenon known as “path dependence”. Once specific trajectories have become dominant, they can be seen as technological regimes.

> “Each technological revolution, originally received as a bright new set of opportunities, is soon recognized as a threat to the established way of doing things in firms, institutions and society at large. The new techno-economic paradigm gradually takes shape as a different ‘common sense’ for effective action in any area of endeavor. But while competitive forces, profit seeking and survival pressures help diffuse the changes in the economy, the wider social and institutional spheres where change is also needed are held back by strong inertia stemming from routine, ideology and vested interests. [...] It is thus that the first 20 or 30 years of diffusion of each technological revolution lead to an increasing mismatch between the economy and the social and regulatory systems” (Perez 2002: 25-26).

Techno-economic paradigms give special weight to the role of technology and use institutions as a selection environment (Green et al. 1999). Breschi and Malerba (1997) have argued that the nature of the technology (technological regime) determines the characteristics of the innovation system. Technological regimes are characterized by four fundamental factors:

- Opportunity conditions: i.e. what are the opportunities to innovate in a certain sector, region or country? Opportunity conditions may be high or low, there may be a rich variety of different opportunities, new knowledge may be pervasive in the sense of affecting different products and markets, and innovative opportunities may arise from different sources (formal R&D, user experimentation, advances in equipment and instrumentation);
- Appropriability conditions: these are generally considered to be essential for innovation processes. If the results from innovation cannot be appropriated by the innovator there is little incentive to invest in innovation. Appropriability levels can be high or low, and there may be different means to appropriate the benefits of innovation (patents, secrecy, continuous innovation, etc.);
- Cumulativeness: this denotes an economic environment characterized by relevant continuities in innovative activities. Cumulativeness may be related to the technology itself. It may also exist at the level of the firm, the sector or the region or country;
- The knowledge base: this includes the nature of knowledge, and the means of knowledge transmission. The nature of the relevant knowledge base can be described in terms of whether the knowledge is generic or specific, whether it is tacit or codified in nature, whether it is simple or complex, whether the knowledge base is independent, or is embedded in a larger system. Effective means of transmission are largely determined by the nature of the knowledge: e.g. in general, the more tacit, complex and part of larger system the knowledge is, the more relevant informal means of transmission are. Formal means of transmission (publications, patents etc.) are more relevant when knowledge is standardized, codified, simplified and independent.

Radosevic (1998) argues that it is the coevolution of institutions and technological regimes that gives coherence and dynamics to systems of innovation. He proposes a classification based on ***structuring forces*** (technological regime or institutional set-up) and on ***mechanisms of selection*** – pre-market and market selection mechanisms in a "selection environment" (Figure 5.3). He then defines a system of innovation as:

> "...a coherent configuration of firms, related institutions, and organizations that are involved in the generalization and utilization of new technologies based on common [technological regimes] and shaped through mechanisms of market and pre-market selection" (Radosevic 1998: 85).

The idea of a selection environment emphasizes the importance of economic, social and institutional factors in shaping a technology (Green et al. 1999).

Figure 5.3 Structuring forces and selection mechanisms

		Structuring forces	
		Technological regime (TR)	Institutional set-up
Mechanisms of selection	Pre-market Selection	TR and pre-market selection: e.g. spin-offs from military program, national security concerns	Institutions determine the character of R&D: funding rules, patent systems etc.
	Market selection	TR as a criterion for market selection: e.g. technology embodied in hardware	Market characteristics determine appropriate organizational models e.g. flexible specialization

Source: based on Radosevic (1998)

Technological regimes and technological paradigms provide the context in which innovation networks or systems operate. They summarize the fundamental factors that describe the constellation of institutional and technological factors that determine how specific innovation processes at the level of individual organizations (farms, firms, R&D laboratories, etc.), sectors, regions or countries.

5.4.2 National systems of innovation (NSI)

Innovation is seen by many as a key component of the "competitiveness of nations" (Porter 1990). The idea of national systems of innovation has become prominent because different countries have organized and promoted innovation in a different manner, and policies that shape the NSI are determined at the national level. Nelson (1993) analyzes the innovation systems of 15 different nations and finds that there are important differences between the NSI of countries such Japan, the USA and Germany. In the introduction to the book a central hypothesis is formulated about:

> "…a new spirit of what might be called 'technonationalism' [...] combining a strong belief that the technological capabilities of a nation's firms are a key source of their competitive prowess, with a belief that these capabilities are in a sense national, and can be built by national action" (Nelson 1993: 3).

Innovation systems are usually defined in broad terms, including horizontal and vertical forms of cooperation, public and private actors, pre-market and market actor institutions, funding and executing organizations, and technology producers and users as well as regulatory organizations and institutions (Freeman 1987, Beije 1998).

While the idea of a NSI may be very useful to Ministries of Science and Technology and for international comparative studies, it is less helpful for understanding actual innovation processes. There are problems both in relation to the **national** aspect and to the **system** concept.

The "system" concept presupposes a well-structured, purposively organized group of actors, whose activities can be clearly distinguished from the system's environment. In the literature there is considerable difference of opinion about the question whether innovation systems are consciously designed by the state and other actors, or whether they are essentially constructs useful for analytical purposes (Edquist 1997: 13). This study follows the second approach as innovation, rather than rationally planned and organized in a systemic fashion, emerges from the bargaining processes between actors with different objectives, power to influence, and resource endowments.

With regard to the "national" level of analysis it may be argued that innovation systems may be both broader and narrower than the boundaries of the nation-state. Increasingly, with advances in information technology and the disappearances of barriers to trade, the market for knowledge and technology becomes an international one. MNEs aim to exploit the benefits of their R&D in other countries through foreign direct investment, by granting technology licenses, or selling technology embodied in capital goods or intermediary products. The innovation activities of MNEs may become part of the national systems of different countries. The effects of such international integration depend on whether a country is the home base of the MNE, or whether it acts as the host country for the company. Similarly, in the public sector there is a long history of international technological cooperation and dissemination of innovations, particularly in the agricultural sector.

On the other hand, at the national level, the components of innovation systems may only be weakly integrated, and a sectoral or regional approach may be more relevant. Nelson (1993) in his study on NSI agrees that there may be little overlap, at the national level, between the innovation systems of, say, the aircraft and the pharmaceutical sector. National systems of innovation can be more or less systemic and the extent of "systemness" is an empirical question (Etzokowitz and Leydesdorff 2000). Beije (1998) sees the NSI as a cluster of interdepending innovation networks and the degree of systemness would depend on how closely the networks are integrated.

5.4.3 Regional and sectoral innovation systems

Paquet (1994) argues that the innovation process even when defined broadly, rarely encompasses the "national" scene, but would appear to be congruent with meso regional/sectoral realities that are the genuine source of synergies and social learning. Paquet finds that ongoing processes of globalization and "balkanization" have triggered processes of devolution and decentralization that have caused "... a shift from vertical hierarchical structures of governance to more horizontal networking structures conducive to innovation conversations." Yet, despite strong arguments to conceptualize innovation at the meso level, the "centralized mindset" continues to provide a predominant and strong underpinning of "technonationalism".

Breschi and Malerba (1997) introduce the concept of a sectoral innovation system (SIS) to address some of the inadequacies of the NSI approach. They define an SIS as a group of firms active in the innovation in a sector. The SIS approach, is structured around firms, but includes other actors as well; it focuses on the competitive relationships between firms (horizontal relationships) primarily, but also addresses vertical relationships and accepts the idea of geographical boundaries of innovative activities. The forces that shape an SIS are related to the nature of the technology and to the technological regime of which it is a part.

Specific properties of technological regimes affect the characteristics of the SIS in terms of the dynamics of innovators (their number, size, etc.), the geographical distribution of innovators (concentrated or dispersed), and the "spatial boundaries of knowledge" for use as an input in the innovative process. Relevant knowledge may be available locally, within national borders, it may flow internationally, or it may be available in specialized centers of excellence.

The discussion of national, regional and sectoral innovation systems leads Edquist (1997: 12) to conclude that:

> ”[s]ystems of innovation may be supranational, national, or subnational (regional, local) – and at the same time they may be sectoral within any of these geographical demarcations. They are many potential permutations. Whether a system of innovation should be spatially or sectorally delimited depends on the object of study."

Industrial complexes often have specific geographical boundaries; and in agriculture the innovation domains are usually determined by a combination of sectoral, ecological, organizational, and institutional factors. Regional clusters of innovation have been widely studied (e.g. Saxenian 1996) and the promotion of such clusters (e.g. in "growth poles", science parks, etc.) has been widely supported by governments in both developed and developing countries. Asheim and Gertler (2005) argue that the "death of distance", proclaimed by Cairncross (2001) is greatly exaggerated and that over time, innovative activity tends to become more clustered, not less. The reason for this is that innovative activity strongly depends on tacit knowledge, which does not travel well as it is "heavily imbued with meaning arising from the social and institutional context in which it is produced" (Asheim and Gertler 2005: 293). When, through the Internet, access to explicit and codified knowledge has become easy, the creation of unique innovative products and services depends on tacit knowledge.

5.4.4 Agricultural innovation systems

Agricultural innovation systems can be seen as sectoral in nature, but with specific geographic characteristics. Agriculture is overall not a high-tech sector where geographic proximity comes at a premium. Rather, agricultural innovation systems are widely dispersed geographically and require transmission of knowledge over long distances of precisely the type of tacit knowledge that does not travel well. Agricultural innovation needs to travel through a range of organizations and institutions as well. At the same time, once available at the local level, new agricultural technologies and practices circulate easily as they are visible in farmers' fields, with limited excludability[19].

FAO and World Bank (2000) have introduced concept of the Agricultural Knowledge and Information System (AKIS) to provide a broader perspective on innovation than the more traditional agricultural research system approach. They present the AKIS as a model that "…links people and institutions to promote mutual learning and generate, share and utilize agriculture-related technology, knowledge and information. The system integrates farmers, agricultural educators, researchers and extensionists to harness knowledge and information from various sources for better farming and improved livelihoods." Röling (1992) presents the AKIS as a soft system that is based on actors (individuals or groups), with fuzzy boundaries and a diffuse goal orientation. Shared learning and communal action are important in soft systems. Development outcomes are the result of negotiation, conflict and consensus.

5.5 Conclusion

Agricultural innovation requires the involvement of a wide variety of different actors and involves joint changes in technologies and institutions. Both the ideas of networks and of innovation systems provide useful conceptualizations to advance our understanding of complex innovation processes. The innovation systems literature emphasizes that there are different levels of analysis: national, regional, and sectoral. The network literature focuses more directly on actors and describes a variety of network arrangements possible in agricultural innovation. Relevant analytical approaches need to describe adequately a globalized world where national as well as international public and private research organizations, life science companies and global retailers increasingly affect what goes on between farmer fields and consumer kitchens. A broadly based agricultural innovation model, which recognizes that there are different technologies, institutions and organizations involved in a number of competing techno-economic paradigms will be developed in the following chapter.

[19] This applies throughout the agricultural sector, including the hi-tech end of the market, as witnessed by the wholesale smuggling on Monsanto's GM Roundup Ready soybean seeds from Argentina to Brazil, which had not licensed the technology, and where they became known as "Maradona seeds".

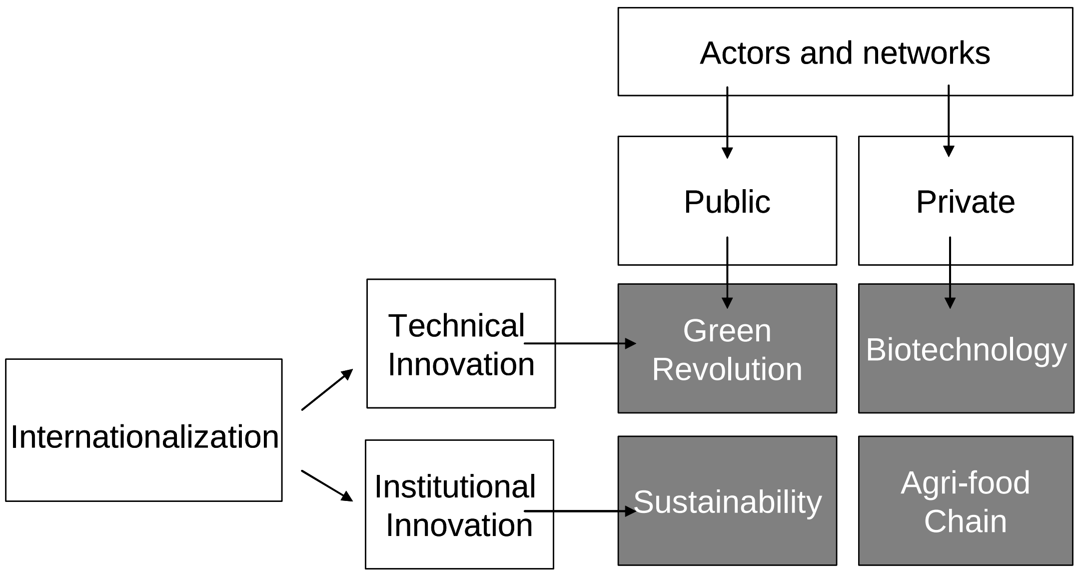
6. Four paradigms in agricultural innovation

6.1 Introduction

The previous chapters presented an analysis of how the co-evolution of institutions and technological regimes gives coherence and dynamics to systems of innovation (Radosevic 1998). Perez and Freeman (1988) introduced the concept of a techno-economic paradigm and they argued that different eras are dominated by different technologies which can be seen as paradigms that compete for dominance. Others refer to socio-technical systems (Geels and Kemp 2007). Ruigrok and van Tulder (1995) introduce the idea of a "concept of control" to describe a number of governance modes of industrial production (such as Fordism and flexible specialization) and which compete for dominance. This study will refer to techno-institutional paradigms to emphasize the roles of technologies and institutions.

In agricultural innovation in Asia four such techno-institutional paradigms can be distinguished. They originate in different time periods, they have different goals and objectives, different key actors and stakeholders and apply different performance criteria. In other words, what counts as performance in one techno-institutional regime may not be seen as performance in other paradigms. The four paradigms result from combining two types of actors and two types of innovation. Core innovation actors may be public or private (as discussed in Chapter 5), and the innovation paradigm may be predominantly technology-based or built on institutional change (as discussed in Chapters 3 and 4). This produces a two-by-two matrix with four distinct innovation paradigms as presented in Figure 6.1.

Figure 6.1 Four innovation paradigms and their drivers



The four paradigms have fundamentally different views about the nature of agricultural development and agricultural innovation – as witnessed by the fact that the four paradigms arose out of four different revolutions: the green revolution, which has the achievement of food security as it priority objective; the sustainability revolution, which led to the paradigm of integrated natural resources management; the gene revolution, which is synonymous with the biotechnology paradigm; and the supermarket revolution, which is based on the rapid development of agri-food chains. Table 6.1 presents a summary of the revolutions and the related paradigms and modes of governance[20].

Table 6.1 Summary of revolutions, paradigms and governance modes in agricultural innovation systems

Revolution	Paradigm	Governance mode
Green Revolution	Green Revolution / Food Security Paradigm	Public, technology dominated, supply-driven
Sustainability Revolution	Sustainability / Natural Resources Management Paradigm	Public, predominantly institutional, demand-led
Gene Revolution	Biotechnology Paradigm	Private, technology dominated, supply-driven
Supermarket Revolution	Agri-food Chain Paradigm	Private, predominantly institutional, demand-led

Given the discussion of the co-evolution of technologies and institutions it follows that the green revolution and biotechnology are predominantly, not exclusively, driven by new technology. Similarly the sustainability and food chain paradigms are not exclusively about institutional and organizational change. But while for example the supermarket revolution would have been impossible without ICT, it is not comparable to the role genetic modification plays in biotechnology. The latter would also have been impossible without ICT and has developed into a discipline in its own right: bioinformatics.
The remainder of this chapter analyzes each of the four paradigms in detail, presents a comparative analysis of the four paradigms and analyzes possible conflicts and complementarities.

6.2 The green revolution and the food security paradigm

The green revolution has been extensively described in the literature. Based on new high yielding varieties (HYVs) of rice, wheat and maize and in combination with agro-chemical inputs and an expansion of areas under irrigation the green revolution achieved spectacular successes, especially in the lowlands of Asia. The green revolution was based on research breakthroughs in the 1940s in Mexico and the new varieties started to be widely disseminated from the late 1960s, especially in Asia. The green revolution was essentially driven by

[20] The different terms used to describe the paradigms in the text are used somewhat interchangeably: e.g. the text may refer to the green revolution paradigm or the food security paradigm; and to the sustainability or the natural resources management paradigm.

international and national public research and extension institutes and supported by international development organizations such as FAO and the World Bank. In the words of Parayil (2003: 974):

> "The Green Revolution is very much a product of technological innovation in the international public domain where Western and Third World governments, public supported non-profit national and international agricultural research institutions, universities, multilateral aid agencies, and Western charitable organizations collectively worked together to increase agricultural productivity."

In the 1960s there was widespread pessimism based on neo-Malthusian analyses of rapidly growing populations and limited growth of production – the "Asian Drama" described by Gunnar Myrdal (1968), and which seemed to be confirmed by widespread famine in India in 1967. The strong international support for the green revolution also had a direct relationship to the Cold War situation in which key Southeast Asian countries as the Philippines and Indonesia were seen as the dominos that might be toppled and fall to communism (Buchanan 1967) .

The basic objective of the green revolution was the achievement of food security, which in the days of high barriers to trade in most countries was interpreted as the need for self-sufficiency in basic food crops, especially rice (Southeast Asia) and rice and wheat (South Asia). The success of the green revolution can be ascribed to a large extent to the single-minded pursuit of the food security objective, which provided clear focus for the efforts of government agencies involved in development and research[21]. The public research effort was made possible by a rapid growth in government bureaucracies that started in the 1960s (Bottema 1995) and which provided the necessary staff in research and extension agencies.

Parayil (2003) describes the green revolution as a post-colonial modernization project aimed at increasing land productivity which was the scarcest factor of production. The new paradigm of the green revolution replaced the older paradigm of subsistence farming that was deemed to be characteristic of "traditional societies". The green revolution can be seen as a Fordist model of production aimed at disseminating a small set of key technologies as widely as possible. Rapid development of irrigation systems provided the basis for a further geographical expansion of areas suitable for application of green revolution technologies, mainly in Asia.

But in the 1980s the limits to the expansion of irrigated areas and more generally the limits of the green revolution became increasingly clear. Land areas that could easily be brought under irrigation became scarce and the technologies aimed at intensifying land use started to run into trouble. Problems of iron and aluminum toxicity emerged in irrigated paddy fields and continuous cultivation of cereals caused serious outbreaks of plant pests such as the brown planthopper in Indonesia. As a result, the green revolution productivity gains occurred in a narrow range of crops and technologies, publicly financed by commodity-oriented, supply-

[21] In many countries such as Indonesia and the Philippines green revolution technologies were pushed hard by government agencies and were sometimes introduced at gunpoint by the army.

driven, national and international research programs (Smale 2005). The green revolution, it was said, had run out of steam.

But Evenson and Gollin (2003) provide a more nuanced picture. Their data (table 6.2) suggest that productivity growth in the late green revolution (1981-2000) in Asia was indeed lower (2.1% p.a.) than in the early green revolution (1961-1980) at 3.6 %. This decline was the combined result of an increase in the contributions of modern varieties (i.e. genetic technology) and a sharp decline in the use of other inputs per hectare. So if the green revolution ran out of steam it was not because of a lack of new genetic technology, but because of problems in support institutions and support policies (irrigation, bureaucracies etc.). The main findings of the Evenson and Gollin study are summarized in Box 6.1.

Table 6.2 Growth rates of food production, areas, yield and yield components

Developing Asia	Early green revolution (1961-1980)	Late green revolution (1980-2000)
Production	3.65	2.10
Area	0.51	0.02
Yield	3.12	2.09
MV contributions to yield	0.68	0.97
Other input per ha.	2.44	1.12

Source: Evenson and Gollin (2003) based on FAOSTAT

The main early criticisms of the green revolution (Griffin, 1979) involved three arguments: that it had not benefited the dryland (upland) areas, that it was environmentally unsustainable, and that it was not scale-neutral i.e. that is was especially beneficial to larger farmers[22]. Subsequent studies (e.g. Prahladachar 1983, Pinstrup-Andersen and Hazell 1985) suggested however that after a time lag the benefits of the green revolution did trickle down to smaller farmers and that in addition important beneficiaries of the green revolution were the urban poor, as well as the rural landless through reduced real food prices. This is not the place to provide an in-depth evaluation of the green revolution – rather the discussion here focuses on the challenges to the green revolution which led to the emergence of the post green revolution model (Byerlee 1992, Gollin et al. 2005).

[22] While the first argument is largely correct, reviews of the second and third have provided different assessments. With regard to sustainability it has been argued (Harrrington 1996) that the highly productive agriculture in the lowlands has significantly reduced the pressure on the ecologically vulnerable upland areas. With regard to the social distribution of benefits, many studies have argued that given adequate government policies Green Revolution technologies did in most cases eventually ‘trickle down’ to small scale producers.

Box 6.1 The origin and dissemination of modern varieties

Evenson and Gollin (2003) in a study commissioned by the International Agricultural Research Centers (IARCs) [23] came to a number of conclusions (based on an analysis of the genealogies of the 8000 most important modern varieties (MVs) produced by the IARCs:

1) Large IARC contributions. More than 35% of MVs released and adopted were based on crosses made in IARCs.

2) Low international flows of MVs crossed by national agricultural research systems (NARS). By contrast, most IARC-crossed MVs were released in several countries.

3) Negligible developed country contributions. Less than 1% of MVs included in their genealogies any crosses made in public or private sector plant-breeding programs in developed countries.

4) Small private sector contributions. Private sector contributions were limited to “hybrid” varieties of maize, sorghum, and millet. Private sector breeding programs for these crops were developed only after “platform” varieties were developed in IARC and NARS programs.

5) IARC research was complemented by NARS breeding. By providing improved germplasm for NARS breeding programs, international breeding efforts increased the productivity of national programs. Because of this IARC-NARS complementarity, the existence of the international centers actually stimulated national investment in NARS research.

6.3 The sustainability revolution and the natural resources management paradigm

The post-green revolution model is based on three different but complementary criticisms of the green revolution: unsustainable cultivation practices, a reductionist approach to agricultural development, and a top-down approach to technology development and dissemination.

The main contributions to the post green revolution paradigm come from three different but related bodies of knowledge:

- The sustainability approach exemplified in the integrated natural resources management (NRM) models that view agriculture, ecosystems and people’s livelihoods in an integrated manner.
- The farming systems approach – an integrated approach against the reductionist model inherent in the green revolution.
- The participatory development approach – an emancipatory approach, against the perceived top-down nature of the green revolution.

[23] More specifically the Standing Panel on Impact Assessment (SPIA) of the CGIAR

The post-Green revolution model amounts to a sustainability revolution, which has in many respects been a "quiet revolution" in comparison to the green revolution. The reasons that this has been a quiet revolution are that it started as a reaction to established policies and strategies, that it expressed itself in different strands, and that it developed in a bottom-up manner. Nevertheless, over the years, the sustainability revolution has led to a new governance model which is being widely recognized by key actors in innovation systems: research institutes, companies and NGOs and which can be identified as the integrated Natural Resource Management (NRM) model.

Douthwaite and Schulz (2001) argue that the paradigm that underpins much of the NRM, Integrated Pest Management (IPM) and participatory research approaches is constructivism, and that the constructivist approach is a reaction to the "hard science" model of positivism. Positivists see knowledge as being independent of context, produced by specialized agencies and to be passively received by users (farmers). Constructivists emphasize that knowledge requires active learning processes. Innovation in the positivist tradition is the adoption of ready made "packages of technology", while in the systems approach innovation requires learning, adaptation, negotiation, and farmer experimentation with new technology. The positivist green revolution strongly emphasized the hard technologies, especially new varieties, which were combined with other inputs in technology packages that were transferred to farmers through government extension agencies. Little adaptation by farmers was deemed necessary or desirable. The systems approaches broadened the scope and meaning of new knowledge in a number of ways. Interaction, farmer learning and technology adaptation, a broad look at performance, including the negative side effects of production, such as increased erosion, and the integrated management of nutrients, pests and diseases are key issues.

A basic principle of the "farming systems movement" Tripp (1991) is that planned agricultural change should be organized around an understanding of farmers' objectives, conditions and priorities. While the focus of the green revolution was on embodied technology (in seed, fertilizer and pesticides) farming systems research (FSR) gives priority to farmer practices in the context of the whole farm as a system. FSR was both a reaction and a complement to the green revolution in the sense that it provided a more holistic approach to the reductionist commodity-oriented model of the green revolution. FSR also represents a different innovation model to the green revolution: while in the latter farmers were seen as passives recipients of technology packages, FSR realizes that farmers are active agents who experiment, learn and adapt technologies to their own needs and integrate them in a complex system of routines and practices. An important contribution of the FSR movement has been its development of new methods for applied and adaptive agricultural research, a prime example of which is the development of participatory approaches.

Participatory approaches in agricultural research and innovation have become increasingly prominent (Ashby 1991, Sperling and Ashby 2001). Participation in agricultural research means that stakeholders, especially farmers, are involved in setting the research agenda. Participation can help achieve a number of goals: greater relevance of research to farmer needs, representativeness of findings, refined insights, and broader ownership of the research and technology development process. Stakeholders can be involved in a number of different ways, ranging from passive roles of providing information to more active roles in decision making, planning and priority setting. Participatory technology development has focused on improving farming practices as well as on developing new varieties (participatory breeding approaches).

6.4 The gene revolution and the biotechnology paradigm

The gene revolution started with the discovery in the 1950s of the DNA structure and the scientific breakthroughs of genetic transformation in the 1970s (Persley 2001). It was not until 1995 that genetically modified (GM) crops became available for commercial release (Qaim 2005). Since then the area under GM crops has grown rapidly (table 6.3). So far growth has been concentrated in a few countries, and has focused on a few crops, and on a few traits (mainly herbicide tolerance, and pest resistance). This is however to underestimate the importance of the gene revolution and the biotechnology paradigm– although GM crops are by far the most visible and controversial biotechnology innovation, there is a range of other technologies that do not involve genetic modification such as tissue culture for propagation of perennial crops, and the use of genetic markers in plant breeding to speed up the varietals selection process.

Table 6.3 Dissemination of GM crop technologies (2005)

Country	Area under GM crops (million ha.)	Percentage of World total	Available technologies[24]
USA	49.8	55.3	HT soybean, Bt maize, HT maize, HT cotton, HT canola
Argentina	17.1	19.0	HT soybean, Bt maize, Bt cotton, HT maize
Brazil	9.4	10.4	HT canola, Bt maize, HT soybean
Canada	5.8	6.4	HT soybean
China	3.3	3.7	Bt cotton
Paraguay	1.8	2.0	HT soybean
India	1.3	1.4	Bt cotton
South Africa	0.5	0.6	Bt maize, HT soybean, Bt cotton
Uruguay	0.3	0.3	Bt maize, HT soybean
Australia	0.3	0.3	Bt cotton
Others	0.4	0.4	
Total	90	100	

Source: based on Qaim 2005 and James 2006

GM technology remains a highly controversial issue (Oskam 2008). Farmers (also in developing countries) love it, consumers and environmental organizations are negative, and

[24] HT: herbicide tolerant; Bt cotton: genetically modified cotton, transformed with a gene of bacterium *Bacillus thuringiensis* (Bt), which confers insect resistance to the plant.

governments find it difficult to formulate coherent policies. The most important issue relates to safety (biosafety and food safety of GM commodities. Another key issue is the ownership of the new GM crop varieties. In the green revolution public organizations played a key role in the plant breeding process and intellectual property remained (implicitly) in the public domain. In the gene revolution the key actors are the private sector life sciences companies who developed the GM crops and who have vigorously pursued their intellectual property rights through legal and (where possible) technical restrictions[25]. Public and non governmental organizations have expressed concern that the new biotech seeds will benefit only the larger, better off farmers. Qaim (2005) however presents information that in many developing countries actual enforcement of IPRs is relatively weak, and that as a result profits for farmers of biotechnology varieties are actually quite high. In addition, while the costs of basic biotechnology research are quite high, the process of plant breeding using the modified material is not highly expensive and can be afforded by many developing countries Lele (2003).

The gene revolution has been seen by some as an extension to the green revolution – thus the title of international conference in New Delhi in 2004 "Agricultural Biotechnology: Ushering in the second green revolution" (GMWatch.org 2004). Others emphasize the differences to the green revolution. Parayil (2003) for example states that the green revolution and the gene revolution are

> "…entirely different socio-technological systems in that these two 'revolutions' involved different technological trajectories that were moulded under different social, political and economic contexts".

Whereas the green revolution was essentially a modernization project, the gene revolution is a product of the modern wave of globalization. The differences between the two revolutions are reflected in the roles of key actors in each. Public sector organizations (national and international) and philanthropic organizations (e.g. the Rockefeller Foundation) played a major role in the green revolution, while the gene revolution is dominated by the private sector and especially MNEs, such as Monsanto. In the gene revolution new varieties are developed to increase shareholder value, not to alleviate hunger and poverty. The new institutions of globalization (e.g. the WTO and the TRIPS agreements) strengthened the role of private ownership and intellectual property rights of the multinational seed companies. These IPRs are vigorously protected by the MNEs through license agreements and through technologies. These changes have caused considerable resistance against both the genetic technology and the MNEs behind the gene revolution and have led to a global reaction by NGOs fighting both the gene revolution and globalization.

Another difference between the green and the gene revolution, and which will likely have a major impact in the long run is related to funding. Since the beginning of the 1990s the international public investments in the green revolution technologies has stagnated and not kept up with the growth in private agricultural R&D (Timmer 2005). The total budget of the

[25] For example the "terminator technology" is a genetic use restriction technology developed to ensure that seeds are … "viable when sold to the farmer, but of which the seeds from the subsequent harvest are sterile" (Visser et al. 2001).

15 CGIAR Centers is around $350 million per year, which is considerably smaller than the R&D budgets of some of the individual plant biotechnology companies[26].

6.5 The supermarket revolution and the agri-food chain paradigm

The supermarket revolution is a very recent phenomenon and according to Timmer (2005: 4)

> "… is transforming food retail markets, and the supply chains that provision them, at a faster pace than anyone imagined at the turn of the millennium, not only in medium income countries, but also in the poorer developing nations".

The supermarket revolution has gone unnoticed for some time because agricultural and trade policy focused almost exclusively on international trade issues while ignoring domestic market dynamics. The supermarket revolution in developing countries is part of a broader new paradigm in which agri-food chains have emerged as a new model of governance at international (global and regional) and at national level.

Since the mid 1990s there has been an increased interest in the development literature in global value chains, global commodity chains, and global production networks. These concepts differ somewhat, but can be traced back to the idea of the value chain introduced by Porter (1990). Two concepts have received considerable attention in the literature: value chain governance and upgrading strategies (Gereffi et al. 2001).

Gereffi (2001) extended Porter's concept to include the international dimension, and distinguished two main types of commodity chains: buyer-driven and supplier-driven chains. These are key actors that organize the chain and which provide governance in the sense of non-market coordination of economic activity. There are also commodity chains which are not strongly dominated by either retailers (buyers) or manufacturers (suppliers. These are traditional commodity chains (e.g. coffee) where transactions are (spot)market-based. Increasingly though, control over the value chain is seen as the key to capturing value-added and economic rents. In addition, in agriculture, concerns about food quality and safety are becoming more important and as a result the controls exercised over food chains become tighter.

Governance in value chains can take the form of vertical integration, (quasi)-hierarchical relationships between lead firms and dependent firms and through inter-firm networks. Core firms exercise control through their market power and their strategic positioning in the chain, which provides some form of monopoly power. This allows core firms in the chain to exercise control over other firms (buyers or suppliers) that they do not own.

In the discussion on how global value chains (and especially in agri-food chains) contribute to innovation the concept of "upgrading" is central. Upgrading involves improvement of

[26] Monsanto, one of the most important life sciences companies, in 2004 had a research budget of USD 500 million. (Source: http://www.monsanto.com/monsanto/layout/media/04/05-10-04.asp, accessed August 2006)

production and logistics (e.g. transport and storage) processes to meet specific and explicit standards. Standards are needed to eliminate risk, which is important in complex chains where quality characteristics may not be immediately evident in the product itself.[27] Standards include government-established safety standards, but industry-defined quality standards are becoming rapidly more important. In fact, so much so that Busch and Bain (2004) have argued that "… the private sector and retailers in particular, together with private standards […] are at the center of the transformation of the global agri-food system".

Upgrading as an innovation strategy may involve product upgrading (new, more advanced products), process upgrading through the application of new technology in production processes, intrachain upgrading, which involves a firm strengthening its position in the chain for example by covering more linkages, and finally inter-chain upgrading, for example a producer moving into a new value chain[28].

What can be seen from the different upgrading processes in value chains is that transfer of technology does play a role in the innovation process, but that the core of the innovation activities in the agri-chain paradigm consists of organizational and institutional innovations. As far as they depend on new standards and contracts it concerns explicit knowledge. But a large part also involves implicit, tacit types of knowledge in improved management practices.

While the global organization of agri-food chains has received most attention, the emergence of regional agri-food chains in Asia has also been very significant and has important implications for agricultural production and innovation systems (Thompson and Cowan 2000). Key changes that have taken place at the Asia regional level and that affect the organization and innovation systems include:

- The disappearance of regional trade barriers and the emergence of regional institutions that foster integration at the regional level have played a major role[29] in the restructuring of production[30].
- FDI at regional level in Asia has increased significantly, not only in industrial production, but also in the agri-food sector (van der Zee 2006). This has led to the emergence of a number of important regional players in the agri-food system such as Thailand's CP group of companies.

At the national level the impact of the supermarket revolution is making itself felt in many countries, starting in Latin America, but followed quickly in East and Southeast Asia and now spreading in Africa as well. At the national level a number of demand and supply factors drive the supermarket revolution. On the demand side the growing importance of

[27] These so-called "credence goods" (Burrell et al. 2006) are goods where quality and safety cannot be known to buyers or consumers through observation or in consumption (e.g. pesticide residues or fair trade compliant production). To ensure quality process controls are necessary.
[28] The establishment by the Colombian Coffee Growers Association in the USA of their Juan Valdez Cafes to compete with Starbucks is a good example.
[29] This involves the South Asia Free Trade Agreement (SAFTA) and the ASEAN Free Trade Agreement (AFTA)
[30] An example is the self-sufficiency in rice policy in Indonesia which has totally dominated agricultural policy for several decades and which (at least de facto) is changing as reliable and cheaper sources of supply are available for Vietnam and Thailand to supplement Indonesia's declining production (Sidik 2004)

supermarkets is driven by essentially the same factors that spread supermarkets in developed countries 50 years ago (Reardon et al. 2003):

- Urbanization, which is separating supply from demand;
- Efficiency gains leading to lower prices for consumers;
- Growing middle class incomes (rising opportunity costs of women's time);
- Increased availability of refrigerators.

On the supply side the rapid spread of supermarkets is caused by:

- Market liberalization in developing countries;
- The flood of FDI available after 1990;
- Saturation of supermarket home-base markets and low margins for in their home countries which propelled the search for higher returns in transition and developing countries;
- The availability of procurement and logistics technology (ICT);
- Declining transport costs (containerization and air freight).

The result has been a very rapid rise of the role of supermarkets in food chains in developing countries which are "increasingly and overwhelmingly multi-nationalized (foreign-owned) and consolidated" (Reardon et al. 2003). The consolidation is achieved through the rapid acquisition of local chains by the international supermarkets.

A key characteristic of the innovation processes that form the core of the supermarket revolution is that they are based on new management technology and on institutional innovation. Some of the innovation trends that can be witnessed include:

- Centralization of procurement to increase overall control over traditionally fragmented markets;
- Imposition of logistics improvements on suppliers to improve efficiency and to reduce the cost of centralization of procurement;
- Growing use of specialized wholesalers by the supermarkets, to achieve quality and reliability;
- Introduction of formal contracts in traditionally fragmented and personalized food sector;
- Introduction of private standards for food quality and safety, as well as the enforcement of public standards not enforced otherwise.

The importance of agri-food chains is likely to increase with the rapid spread of ICT. Gereffi (2001) indicates that electronic commerce will change the distinction he made earlier in producer and buyer- driven value chains.

While the supermarket revolution presents opportunities for farmers to diversify out of low-value crops and to upgrade to new higher-value commodities, there is also the real risk that especially the smaller farmers cannot meet the increasingly tough standards imposed by the supermarkets and which may push them out of lucrative production niches. Whether agri-food chains are effective development instruments is therefore an open question, which also has relevance for the role of actors outside the agri-food chain, especially governments.

6.6 Conflicts between paradigms

The key characteristics of the four paradigms are summarized in Table 6.4. From the table and the discussion above the main conclusion is that the four revolutions represent fundamentally different paradigms when considering when and where they originated, who are the key players, the role of institutions such as IPR, the of public goods, and the types of technologies and innovations they generate. It should therefore be no surprise that there is considerable conflict between the four paradigms on a number of key issues:

- Ethics: genetic transformation remains a contentious issue;
- Health and safety of GM foods for consumption;
- Biodiversity, which may be threatened by the spread of modern varieties and GM crops;
- Ownership: public vs. private nature of intellectual property and common resources;
- Role of technology: technological innovation vs. social change;
- Regulations and policy instruments;
- Innovation process: technology push vs. demand-led innovation;
- Impacts on poverty.

These issues continue to be hotly debated in the national and international innovation arenas. But while there are important differences and major sources of conflict between the paradigms, another way of looking at them is as ideal types or models of innovation. In that case it is possible to identify initiatives and models that aim at conflict resolution. And while innovation takes usually takes place within paradigms, based on “normal science” in the Kuhnian sense, the most important innovations often take place as a form of paradigm shift, leading to radical or systemic revolutions. Table 6.5 identifies for each pair of paradigms the major sources of conflict and the conflict resolution strategies and initiatives.

The conflicts between the green revolution and biotechnology paradigms were discussed above, based on Parayil (2003) and concern mostly the public nature of the new technologies. Thus, the CGIAR (the major provider of international public agricultural R&D) is criticized by NGOs for getting too close to the private sector and adopting IP protected technologies from the private sector. New institutional arrangements are being developed to solve this conflict. Life science companies such as Monsanto make available protected technologies for use by developing country farmers following certain restrictions. The International Service for the Acquisition of Agro-biotech Applications (ISAAA) has been supported by donors to act as intermediary between public and private actors in this field.

The sustainability paradigm was an initially strong reaction to the green revolution, especially to the latter’s support of unsustainable practices as discussed above. The initial conflict of productivity vs. environment has largely been resolved and many sustainable practices and approaches such as farming systems and integrated pest management have been widely adopted in conventional commodity research.

Table 6.4 Four paradigms in agricultural innovation

Paradigm	Revolution	Take-off	Type of technology	Innovations	Key actors	Nature of the innovation process
Food security	Green revolution	+/- 1970	Seed / fertilizer packages Hard, embodied technologies	High yielding varieties Agrochemicals Component technology Technology packages Mechanization	International public sector research orgs. National public sector research orgs. Public support institutions Charitable foundations	Technology push Genetic technology and other inputs
Integrated Natural Resources Management	Sustainability revolution (post-Green Revolution)	+/- 1985	Improved management practices Soft, tacit technologies	Sustainable practices Land management, Zero tillage Crop-livestock interactions Multiple cropping Participatory breeding	Civil Society orgs. Farmer orgs. Small scale private Charitable orgs NGOs (International and national)	Demand-led Participatory approaches Management technologies
Biotechnology	Gene revolution	+/- 1990	Genetic modification Tissue culture Genetic markers Hard, embodied technologies	GM crops Marker assisted breeding Tissue Culture plant propagation	International Seed and Biotech Companies WTO NGOs	Technology push Technical change Institutions regulation (macro)
Agri-food Chain	Supermarket revolution	+/- 2000	Logistics, management ICT Institutional change	Chain management Chain upgrading Private Standards Contract farming	International retailers agri-food chains National chains and retailers Commercial growers Consumers?	Organizational change Micro institutions Demand-led

Conflicts between biotechnology and sustainability paradigms concentrate on IPR and access to (embodied) technology. There is concern that increasing IPR protection by the private sector of biological materials that were traditionally part of the public domain (such as traditional varieties stored in gene banks) will no longer be available for crop improvement in the public domain. At the same time biotechnology has the potential to contribute to sustainable production practices by reducing the use of pesticides in a major way (as is already happening in cotton), or by contribution to erosion control using zero tillage practices.

Table 6.5 Conflicting paradigms and resolutions

Paradigm pairs	Conflict	Resolution
Green Revolution – Gene Revolution	Use of privately owned GM germplasm in public plant breeding	Access to protected germplasm (ISAAA)
Green Revolution – Sustainability Revolution	Unsustainable practices	Incorporation of sustainability in CGIAR Center work
Green Revolution – Supermarket Revolution	Use of agrochemicals, pesticide residues	
Gene Revolution – Sustainability Revolution	IPR, Access to technology	“Tailoring biotechnologies”
Gene Revolution – Supermarket Revolution	Consumer rejection of GM foods	none
Sustainability Revolution – Supermarket Revolution	Supermarket power *vis-à-vis* suppliers Increasing length of food chains, energy use Food miles	“Fair trade” Sustainable Development Initiative (Unilever, Nestlé)

Conflicts between the green revolution and the supermarket revolution are limited. The most important issue is probably related to pesticide residues in food products produced under modern, highly intensive production systems. Possible conflicts between the sustainability paradigm and the agri-food chain paradigm relate to supermarket demands for low-cost products squeezing supplier margins and contributing to non-sustainable practices. The emergence of globalized food chains has brought to light the issue of unsustainable practices in relation to “food miles”.

Finally, a major conflict exists between biotechnology and the supermarkets as a result of the general rejection by consumers of GM products. Supermarkets are therefore quite reluctant to stock GM products and are concerned that their products may contain traces of GM commodities (due to the difficulty of “chain separation”). There seems to no easy solution to this conflict – though it is increasingly likely that the issue will be forced by the very rapid expansion of areas cultivated with GM crops since the year 2000 (Business Week 2007) and the practical impossibility of separating GM from GM-free chains.

6.7 Conclusion

The key conclusion from this chapter and indeed from part I of this study is that agricultural innovation is not only an interactive process involving a variety of public and private actors. More fundamentally, agricultural innovation encompasses a number of entirely different – often rival – techno-institutional paradigms. These arose at different periods of time, are dominated by different actors and are based on fundamentally different technologies and institutions. They create a particular ‘selection environment’ for technological and institutional change trajectories, and thus ultimately also for systemic performance. Agricultural innovation can only be properly understood when these different paradigms are taken into consideration in conceptual and empirical research.

Part II Drivers, Paradigms and Performance in Asian Agriculture

7. Performance and agricultural innovation

7.1 Introduction

Part II of this study contains an empirical analysis of agricultural innovation in Asia and analyzes how performance differs between organizations, countries and paradigms. This chapter provides an introduction to the empirical analysis of innovation performance by discussing the concept of performance, and its measurement and evaluation at different levels of analysis.

The basis for the study of innovation performance is the understanding that innovation actors such as research organizations and private companies not only need to be productive organizations that generate new technologies or products, but that the outputs they produce must be relevant to the needs of customers, clients and stakeholders. Productivity (efficiency) and relevance (effectiveness) are the two main dimensions of performance. Performance is closely linked to accountability, particularly in the public sector. Research organizations are held accountable for a certain level of performance by their parent Ministry or funding agency (Premchand 1993).

On the other hand the measurement of performance can be seen as a precondition for accountability, as it allows the organization to communicate performance information to stakeholders. While in the private sector market share and profitability provide fundamental indicators of a company's performance, such mechanisms are usually missing in organizations that produce public goods. Thus, accountability mechanisms are instrumental to improve performance, but they are also important in their own right: to account for public resources used and results achieved.

Part II of the study applies the conceptual framework developed in part I and analyzes agricultural innovation processes in Asia at a number of levels, and in relation to four different countries:

- Performance of individual public research organizations;
- Performance of private sector companies in agricultural innovation;
- Linkages and networks in national innovation systems;
- Drivers and paradigms in Asian agricultural innovation;
- National R&D and innovation performance;
- Agricultural sector performance.

The performance sequence presented in the above list resembles the "impact chain", which starts with analysis of outputs produced by innovation actors (companies and research organizations), and proceeds to the outcome level and the dissemination of research results in innovation networks. In another step the study analyses how innovation drivers and the four agricultural innovation paradigms in have performed in Asia. Finally, at the macro level the analysis focuses on the performance of national innovation systems and of the agricultural sector.

It is well known from the evaluation and impact assessment literature (Patton 1997) that considerable time lags exist between the production of (research) outputs and their eventual effects on productivity, and that the attribution of increased productivity to R&D and innovation is difficult, as many other interventions also influence productivity. As well, the impact chain, like the innovation process is not linear: changes in the national innovation system are not only the outcome of R&D and innovation outputs, they form the selection environment in which subsequent innovation activities take place. For the sake of presentation the empirical analysis in the following chapters applies an "outside-in" perspective, starting with macro-level agricultural sector and innovation system performance and proceeding to the performance of drivers, paradigms, networks and public and private innovation actors.

Part II applies the empirical analysis to four Asian countries: Indonesia, Pakistan, Sri Lanka and Vietnam. These countries participated in a project entitled "Performance Based Management Systems for Asian National Agricultural Research Systems" (PBMS). This project was implemented from 2000-2003 by the International Service for National Agricultural Research (ISNAR) in close cooperation with national agricultural research institutes in the four countries. The selection of countries for the project was the result of a consultation between ISNAR and the project sponsor, the Asian Development Bank. The selection aimed at including countries from the two subregions: South Asia and Southeast Asia. It also aimed to include countries with different profiles regarding agricultural R&D organization and governance. The project provided an opportunity to conduct extensive field work in those countries, involving not only the national level agricultural research councils or governing bodies, but focusing specifically on six research institutes which worked with ISNAR (and networked with each other) to assess and improve performance in a number of ways, including organizational performance, staff performance, the establishment and management of linkages with other actors in the innovation system, and the selection of research priorities. In the process, information was also collected on private sector activities in agricultural innovation in the countries. The project work provided a rich source of information at the level of innovation actors. In the subsequent elaboration of the study this was complemented with secondary data from a wide variety of sources.

7.2 Conceptual issues

7.2.1 What is performance?

There is no universally valid definition of performance. "Instead, 'performance' is socially constructed reality that exists in peoples minds" (Wholey in Mayne and Zapico-Goñi 1997, viii). The performance of an organization is closely linked to its goals and objectives. Agricultural research organizations, for example, may define performance as the quantity and quality of scientific publications produced, or they may define performance in terms of technologies adopted by farmers. Because performance is a reflection of an organization's goals, strategic objectives, and values, performance measures have to be specific to the type of the organization and they have to be acceptable inside the organization and credible to outside principals and stakeholders.

In addition, as discussed in detail in the previous chapter, in agricultural innovation there are different schools of thought or paradigms that may have radically different ideas about the nature of performance. For example, crossbreeding of local cattle with imported animals in India, which most researchers would see as “genetic improvement”, has also been referred to as “ecocide of indigenous cattle breeds” (Shiva 1996).

Performance has been defined by Mayne and Zapico-Goñi (1997) in terms of the “three Es” of economy, efficiency and effectiveness. Economy refers to the wise use of inputs and the elimination of waste. Efficiency refers to the ratio between inputs used and outputs produced and has been defined by Drucker (1985) as “doing things right” in an operational sense. Effectiveness (defined by Drucker as “doing the right things”) is directly related to an organization’s objectives, strategy and the unique way in which it attempts to establish a competitive position, or to carve out a niche vis-à-vis competing organizations.

Schumann et al. (1995) argue that R&D organizations should mainly focus on improving their effectiveness. This contrasts with industrial production, where the emphasis is appropriately on improving efficiency as there is usually tremendous leverage in reducing costs and eliminating defects. But as R&D costs in companies are usually only 5-10% of production costs, the scope for improvement through efficiency gains is limited. Instead, in R&D the focus should be on effectiveness, as the leverage here is often ten to hundreds of times the R&D costs. The revenues from a really innovative product or process will dwarf the revenues from efficiency programs. Even if there are many R&D projects that do not produce measurable results, they are important in organizational learning and will play a crucial role in producing a small number of “blockbuster” innovations that generate sufficient revenue to repay the investments made in R&D many times over. Effectiveness is therefore the key concept in the definition of R&D and innovation performance.

In public and non-profit organizations effectiveness is directly related to the idea of relevance. An organization is ineffective because it “does the wrong things”, it provides the wrong types of products and services to clients, or it is not focused on the needs of clients or stakeholders at all. To ensure that organizations stay “on the right track”, they require well-designed accountability mechanisms. Thus, the concepts of performance and accountability are closely related. In Premchand’s (1993) view organizations and individuals should be accountable for specified levels of performance. The required levels of performance can be negotiated or imposed, depending on the power relationships between the actors concerned. Accountability refers to the mechanisms by which decision makers are held responsible for performance by those affected by their decisions. Performance and accountability questions may relate to the use of resources, the quality of internal processes, compliance with rules and procedures, the production of outputs, the achievement of impact, and the continued relevance of mission and programs of work.

Resource use

At the organizational level performance and accountability of resource use relates to human, financial and physical resources. An organization is accountable to different parties: its own staff, its board or oversight body, shareholders, donors and other external stakeholders. Staff are a key resource in any knowledge intensive organization and it is important that they have a clear understanding of what is expected of them (job descriptions), that tasks are well defined and that procedures for staff evaluation and staff development are in place. With regard to financial resources it is important to know whether the organization produces adequate financial and other reports.

Processes

Organizations can only be accountable for performance if their objectives are clear, well understood and translated into specific tasks and work processes to be performed by units and individuals. Often, the tasks that an organization is expected to undertake are not well defined. Several issues arise in assessing the processes that an organization can be held accountable for. They relate to task specificity i.e. whether the organization's processes and tasks are well defined and understood – a precondition for being able to assess accountability. Processes need to reflect the longer-term objectives of the organization. Setting the research agenda of the organization through planning and budgeting, monitoring its implementation, and evaluating its results on a regular basis are key organizational processes required for performance measurement and accountability.

Compliance

Every organization whether public, private or voluntary, has laws, rules, regulations, standards, protocols, codes, and procedures to follow. Some of these are externally imposed, while others are developed by the organization itself. As long as there is a single organization, the design of rules and regulations takes place in a distinct hierarchy. In the case of multi-organizational arrangements, such as networks and partnerships, setting the rules and enforcing compliance with these rules, often results in difficult negotiation as there is no clear central authority. Accountability requires that the "rules of the game" are clear to the different actors (individuals, units, participants in networks, etc.), that processes and procedures are followed, and that adequate reporting mechanisms are in place. Compliance needs to be enforced and appropriate mechanisms and procedures are required.

Outputs and impact

As a result of the ideas of the new public management a clear shift can be observed from accountability for resources and procedures to accountability for results or performance. Financiers increasingly demand evidence not only of productivity, but also of impact on clients and on economy and society. Within the context of a single organization, the attribution of results is easier than in a more complex organizational arrangement. Accountability for performance requires information on the quantity, quality and relevance of outputs. Responsibilities, attribution and contributions need to be determined, not only for immediate output, but also with regard to the longer-term impact of the organization.

Continued relevance to different stakeholder groups

Organizations must adapt to changing circumstances and demands. Those that fail to do so will find that they are no longer relevant and receive diminishing support from their stakeholders. An important aspect of accountability is to verify that the organization's mission and mandate remain relevant, and that it is responsive to its direct clients and to a broader stakeholder community. Changes in stakeholder characteristics and attitudes and an increase or decrease in the number of donors are significant. Responsiveness to stakeholders is also reflected in the number of new and innovative services and products that the organization produces. This is especially difficult when there are internal and external stakeholders who have different views about the issues to be addressed and methods to be used. Over time, new approaches, methods and entirely new models and paradigms emerge and compete with earlier models. In agricultural innovation it is difficult for research and technology organizations to address performance questions related to the radically different innovation paradigms presented in chapter 6.

7.2.2 Why measure and assess performance?

The purpose of measuring and judging performance is to improve it. This section discusses the question whether measurement improves performance. It analyzes the link between indicators and performance and presents some common problems. The next section presents an alternative to performance measurement: the introduction of incentives and competition.

"What you measure is what you get" (Kaplan and Norton 1992). Measurement systems strongly affect the behavior of managers and employees, especially if rewards, incentives and sanctions are linked to performance targets and assessment. But performance is a complex phenomenon and making it measurable through indicators is a difficult task. The problem with indicators is that they must be relatively easy to measure and therefore necessarily simplify complex performance dimensions.

The performance assessment literature is divided between those who feel that using performance indicators and benchmarking one's performance against colleagues and competitors are powerful tools to reorient individuals and organizations towards outputs and outcomes, and those who feel that performance measurement and assessment frequently fail to improve it. The supporters of performance assessment can be found especially with management specialists and consultants. And while the best management texts provide balanced views and sensible proposals (e.g. Rummler and Brache 1995, Kaplan and Norton 1992, 1996, Szakonyi, 1994), there is also a tendency for management consultants to oversell what can be achieved through performance assessment.

Performance assessment has drawn criticism, especially for orienting behavior towards easily quantifiable indicators. If these indicators are a poor representation of the ultimate performance goals, and if rewards and sanctions are directly linked to performance as measured by the indicators, the measurement and assessment may divert or even subvert the improvement of performance. Performance measurement can have "unintended consequences" (Smith 1995) or can be downright "dysfunctional". Dysfunction of measurement is defined by Austin (1996: 10) as: ".... consequences of organizational actions that interfere with attainment of the spirit of stated intentions of the organization. That dysfunction is violation of the spirit and not the letter of stated intentions is important."

Smith (1995) reviews unintended consequences of performance measurement especially for public sector organizations where goals are often less precise and more contested than in the private sector. He presents eight possible unintended consequences that are the result of a lack of congruence between the goals of the agent (moderated by rewards and incentives) and the actual goals of the principal.

Performance measurement may encourage “tunnel vision”: an emphasis on what can be quantified at the expense of unquantifiable aspects of performance. Tunnel vision leads to “suboptimization”: the pursuit of narrow local objectives at the expense of wider organizational goals. Public sector goals and objectives are often long-term in nature, while measurement encourages short-termism and “myopia”. Also, the use of indicators may encourage “measure fixation”: an emphasis on the measures at the expense of the underlying objectives.[31] Excessive reliance on performance indicators may also lead to “misrepresentation” by the agents (= managers): a deliberate manipulation of information so that reported behavior differs from actual behavior. “Gaming” is the opposite: the manipulation of actual behavior, a dysfunctional situation that occurs when managers expect that achieving this year’s performance standard will result in tougher standards in years to come. Additional problems include “misinterpretation”, which happens in complex situations where performance indicator information fails to provide the right signals; and “ossification” where the rigidity of measurement systems causes organizational paralysis.

A major problem with performance-based systems (consistent with the observations of principal-agent theory, is that people often react to measurement with unexpected sophistication. A natural response to perceived failures of performance is to introduce added rules. Rules, however, serve not merely as controls but also define minimally acceptable behavior. Managers who apply rules to subordinates in a legalistic and mechanical way, invite “working to rules,” which frustrates effective performance (Williamson 1996). Fortunately, the fact that agents react in predictable ways to measurement also suggests opportunities to strengthen the link between measurement and improvement of performance. Transparency, staff participation, flexibility in the system, a focus on client satisfaction, independent advice on measurement, careful audits of the data are among the most important success factors for performance assessment.

7.3 Measuring and evaluating performance

The emphasis on performance represents a shift from inputs and internal processes to outputs for clients and to outcomes and impact for stakeholders and the general public. With regard to agricultural research and innovation a number of different approaches can be distinguished:

- Economic evaluation of research outputs and outcomes
- Program evaluation approaches
- Performance indicators
- Impact assessment

[31] The U.K.’s Patient Charter stated that no one should have to wait more than two years for surgery. That target was achieved, but the number of patient waiting more than a year increased and average waiting times increased as well. More serious was that to achieve the performance target, “easy” patients, requiring relatively minor surgery appeared to be given priority to those with more severe conditions (Smith 1995).

- Performance audits
- Organizational performance assessment models

7.3.1 Economic evaluation

The general model in the economics tradition is to consider agricultural research as in investment, yielding a stream of future benefits. This allows the use of cost-benefit approaches that can be used either ex-ante to estimate future benefits of alternative investments, or ex-post to determine the benefits of past investments. Social cost-benefit approaches allow the incorporation of exogenous elements in the analysis using weights and shadow prices. In its most developed form “economic surplus analysis” assesses the future net benefits that accrue to producers and consumers respectively, from a stream of research investments (Alston, Norton and Pardey 1995). Economic surplus analysis has been widely applied to determine rates of return to research in an ex-post setting[32]. The most thorough meta-analysis of rate of return studies conducted to date (Alston et al. 2000) concluded that returns to agricultural research investment are usually well above a social discount rate.

Economic surplus analysis allows estimation of the broader economic and societal impact of agricultural research investments by incorporating in the analysis spillover effects from research carried out elsewhere, and including societal concerns over environmental impact and the effects on different social groups in the analysis. International donors (who fund a significant part of international public agricultural research) increasingly demand this type of information. But the wider the impact assessment net is cast, the larger the amount of data required, the more heroic the assumptions made, and the more difficult the analysis becomes. This explains why, despite significant investments in impact assessment work in agricultural and other research sectors, little progress appears to have been made.

7.3.2 Program evaluation approaches

The evaluation of programs and projects has become an important professional field (Patton 1997, Horton 1998). Many public sector programs are periodically evaluated using methods such as peer review, external expert review, bibliometric studies and other methods. The program evaluation approach has its roots in the social sciences and is widely used in external evaluations of specific programs as well as organizations.

Program evaluation in one form or another may take place at different stages of the research management cycle, both ex-ante and ex-post. Ex-ante research evaluation (also known as “formative” evaluation) includes the appraisal of project proposals and the selection of research priorities. Ex-post evaluation reviews and judges the immediate outputs (products) generated. It may also include an assessment of final outcomes, or impacts. A comprehensive evaluation process however not only reviews the immediate and longer term results, but also assesses the process through which the results were produced, the inputs used and the context in which the activities took place (Horton et al. 1993).

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[32] While theoretically the most rigorous approach for ex-ante assessment of future benefits, economic surplus analysis has not been widely or successfully used in this respect. It requires heroic assumptions about future adoption rates, social discount rates, prices and price elasticities.

Some program evaluation approaches have moved beyond the technocratic external expert reviews to include participants and stakeholders in participatory evaluations, while more radical approaches in the constructivist tradition (Guba and Lincoln 1989) reject the notion of outsiders reviewing programs and hold that evaluators and stakeholders jointly create the product of evaluation.

7.3.3 Performance indicators

Performance measurement has become very popular since the 1980s and there is a large literature on the subject. Managers are often invoked to focus only on those things that can be measured and ignore things that cannot be quantified. Considerable experience with performance measurement (both positive and negative) has been obtained and a large number of assessment and measurement systems have been developed.

Performance is a complex construct and cannot be directly observed or measured. Instead performance assessment relies on indicators or metrics that can be measured. Good indicators are related to and operationalize key aspects of an organization’s strategic objectives (Bavon 1995, Kaplan and Norton 1992, 1996). Indicators can be classified as being quantitative or qualitative, and may be output or outcome oriented. Different types of indicators may be combined in performance assessment systems.

Quantitative indicators may be distinguished in objective and subjective types (Werner and Souder 1997). Examples of objective quantitative indicators are: number of publications, patents registered, or technical recommendations released. Quantitative indicators that are subjective in nature are judgments converted to a numerical using, for example a five-point scoring scale. The advantage of quantitative indicators is that they are easy to use and facilitate comparison over time or between organizations. This is, at the same time, a danger: they can easily be misrepresented or misinterpreted if contextual information is not taken into consideration.

Qualitative indicators are quite different: they include self-evaluations, supervisory ratings, peer reviews and external audits or reviews. Qualitative assessments are suitable for situations that defy easy quantification. They often provide an in-depth look at the performance of organizations, units or individuals, and they often require intense interaction between parties involved in an assessment.

7.3.4 Outcome indicators and impact assessment

Programs are designed to deliver specific outputs (goods and services). At the output level there is a direct link between the program activity and the output produced. But managers and especially policy makers are normally not satisfied with output data: they require information on a program’s reach, and on the intermediate and final outcomes (results) of a program. This is known as the impact chain which ranges from inputs to processes to output, to outcomes and impacts. The main problem here is that with every step away from the direct outputs produced by an organization or program, the question of attribution becomes more pertinent (Mayne 1999). What has research, in fact, contributed to the adoption of new technologies (as opposed to, for example, the role of subsidies, farmer experimentation, and supporting services such as credit)? Mayne proposes to use a procedure known as “contribution analysis” that focuses explicitly on the issues of attribution and contribution and that aims to present a credible story of how a program or project contributes to solving a problem.

The attribution/contribution problem explains why simple sets of quantitative impact indicators are unlikely to be successful. There are simply too many intervening variables to assume, for example, that a decline in child malnutrition has been caused by poverty-oriented agricultural research programs (Alex 1996).

7.3.4 Performance audits

Auditing has always been an important accountability tool, providing managers, boards and external stakeholders with information about the use of resources by the organization. Auditing has moved beyond the traditional approach of “reviewing the books” to include more wide-ranging questions e.g. whether the organization is providing value for money. “Comprehensive auditing” (also referred to as performance auditing) is an approach that has been developed in Canada and is increasingly applied in many countries to review the economy, efficiency and effectiveness of organizations (CCAF 1994). The development of comprehensive auditing arose from a need to provide better information to governing bodies on the performance of organizations. As such, it implies a shift from accounting for resource use to accounting for results achieved. Performance audits often use a system of organizational performance assessment to obtain a complete performance picture.

7.3.5 Organizational performance assessment

Organizational Performance Assessment has its roots in the field of management. The development of performance measurement systems that often include a variety of quantitative and qualitative indicators or metrics has become an important area and has received much attention from academic researchers as well as from management consultants.

As performance is a complex issue, many authors have argued for the use of systems that combine quantitative and qualitative indicators and that focus on outputs and outcomes, keeping in mind the high cost of assessing outputs and outcomes in a credible fashion. Kaplan and Norton (1992) have developed a performance instrument known as a “balanced scorecard” that includes “measures that drive performance”. The model has become widely used in business, but also in adapted form to assess research and technology departments (Kerssens-van Drongelen and Bilderbeek 1999). The balanced scorecard includes the standard financial performance indicators, but the authors feel that these provide an incomplete picture of what drives performance. The scorecard uses indicators under four different perspectives:

- Financial perspective (cash flow, sales growth, market share, profit)
- Customer perspective (on-time delivery, partnerships, new customers)
- Internal business perspective (capabilities, excellence, productivity)
- Innovation and learning perspective (technological leadership, new products, time lags to develop new products)

To assess performance, individual organizations need to develop specific indicators under the four perspectives to suit their particular needs.

Peterson et al. (2003) have developed an organizational performance assessment system (OPAS) tailored to the use of agricultural research organizations. It combines quantitative, objective and subjective measures in a framework that consists of two components. The first is an output assessment system that identifies and counts the specific outputs of the institute in a number of categories: varietal improvement, crop management, dissemination, training, public services etc. The categories and the specific outputs in each differ from institute to institute. The second component is adapted from Szakonyi (1994a, 1994b) and assesses strengths and weaknesses in ten management areas that drive performance. The ten areas include assessment of the external context of the institute, how it plans and sets priorities, and how it manages projects, staff and information.

7.4 Performance assessment at different levels of analysis

Performance and accountability in agricultural innovation involve a variety of actors at different levels. The assessment of performance at the national level is different from assessments at the level of individual organizations or interorganizational networks and requires different information and procedures. Figure 7.1 presents an overview of the different levels of assessment and their characteristics.

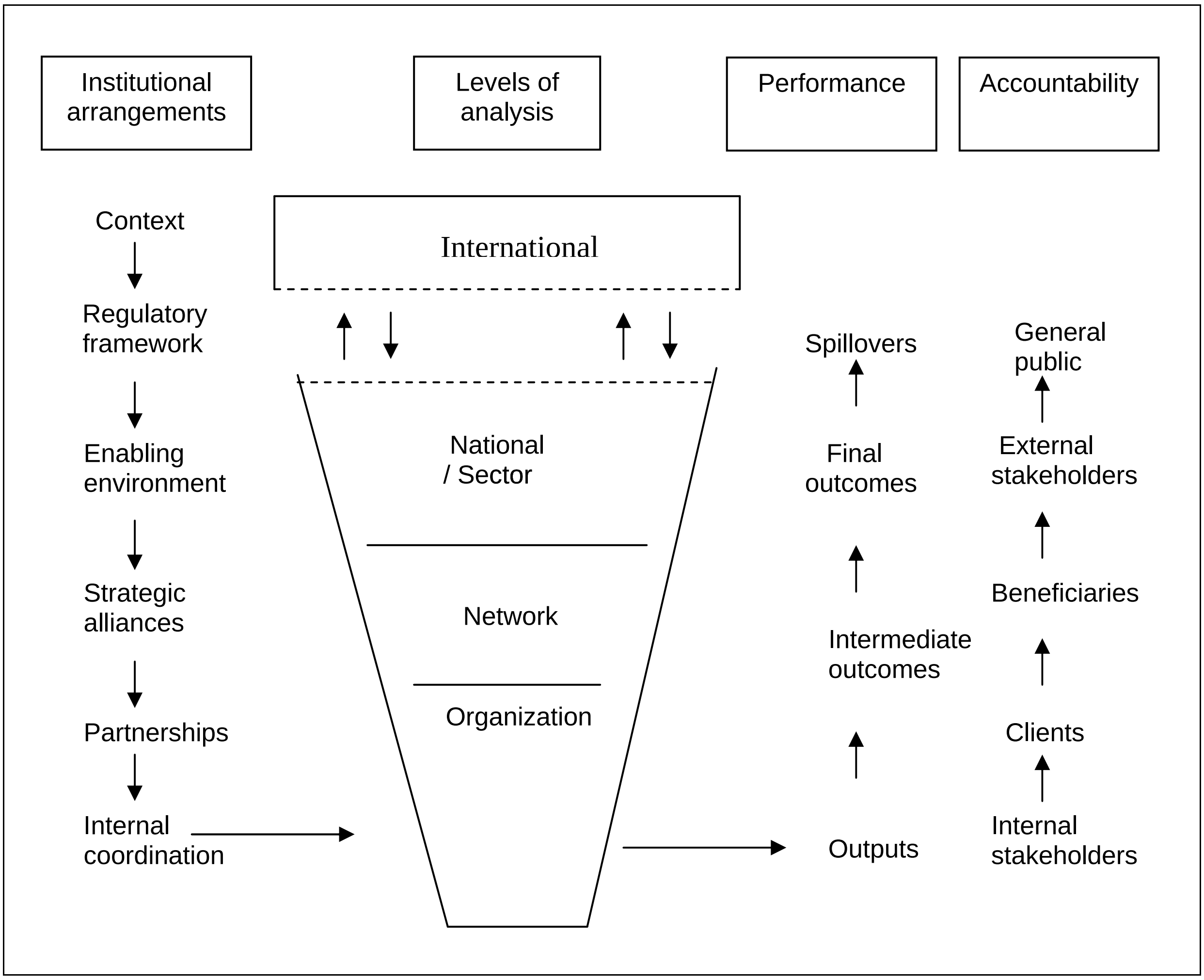
At the level of the organization the assessment of performance and accountability focuses on outputs produced, and on the key organizational processes that drive productivity and relevance to stakeholders. Outcomes are realized when outputs are disseminated to and adopted by other actors.

Interorganizational networks provide a key enabling environment for organizations to produce results, and they are essential in disseminating and adapting new technologies. As such, networks are the appropriate level to assess intermediate outcomes. The analysis of networks focuses on the actors involved, the nature of their interactions, and their contributions to the production of relevant outcomes.

The national or agricultural sector level provides a more contextual type of enabling environment for organizations and networks. The national level policy and regulatory framework provides incentives that steer organizations and networks either towards or away from productivity and relevance. On the output side, variables related to outcomes are best measured at this level as they usually involve aggregates.

The international level is increasingly important in steering national innovation systems because of increased trade in agricultural products, as a result of the rules, regulations, and standards imposed by international bodies and through the activities of multinational companies that invest in production, technology and trade. At the output side there may be important spillovers, internationally, from activities in countries.

Figure 7.1 Performance and accountability at different level of analysis



7.5 Conclusions and next steps

Performance includes efficiency and effectiveness dimensions. Performance is context and paradigm specific, and depends on the objectives and mandate of an organization. Performance measures need to be tailored to specific (types of) organizations.

While performance at the organizational level can be measured using a variety of approaches, indicators and measurement systems, it is more difficult to assess performance at the levels of agricultural sector, or nationally. Measurement is complicated by the fact that innovation is complex phenomenon which involves a variety actors and systems. Data limitations further complicate the analysis of innovation and performance of innovation actors. To analyze agricultural innovation in Asia, the following chapters present the performance question from a variety of angles and different levels of analysis.

Chapter 8 starts at the most aggregate level of agricultural sector performance in four countries: Indonesia, Pakistan, Sri Lanka and Vietnam. The link between agricultural innovation and agricultural sector performance is difficult to establish due to time lags and the fact that many other factors contribute to sector performance. Therefore the analysis is complemented by an assessment of the innovation systems of the four countries, based on published data.

Chapter 9 analyzes performance of the three drivers of innovation: internationalization, technical change and institutional change and assesses how the four different countries have responded to internationalization, invested in R&D and adopted models of institutional change conducive to agricultural innovation.

Chapters 10 and 11 consider the types of actors involved in agricultural innovation: public and private. In chapter 10 specific attention is given to the performance of agricultural R&D organizations, based on information collected at a number of research organizations. The analysis of private sector performance is based on interviews at a number of companies and on secondary data. Special attention is given to the interorganizational linkages necessary for the generation and dissemination of innovations.

Chapter 12 elaborates on this analysis by providing a synthesis of the previous two chapters through a review of the presence of agricultural innovation networks in the four countries.

8. Agricultural growth in Asia: patterns of productivity and performance

8.1 Introduction

This chapter focuses on two concerns at the basis of this study: questions about the uneven performance of the agricultural sector in Asia and worries about declining performance of the public agricultural R&D systems that supported agricultural innovation processes in the past, but that fail to address the needs of increasingly diverse and complex agricultural production systems. The purpose of this chapter is to review the performance of the agricultural sector as well as the performance of the innovation system based on an analysis of secondary data from different sources. This analysis provides a first approximation of the performance question, which will be addressed more in-depth in subsequent chapters.

Section 8.2 reviews the evidence of trends in productivity and performance over time, for different (sub) sectors (food crops and plantation crops) and for different sub-regions and countries. Section 8.3 reviews the limited data on performance of the R&D and innovation system in order to determine what patterns of performance can be observed. Conclusions are presented in 8.4.

8.2 Agricultural sector performance reviewed

Asia's agricultural sector has experienced spectacular production growth since 1975. Cereal production (table 8.1) in developing Asia almost doubled from 542 to 1023 million tons between 1975 and 2005. But production increases tell only part of the story as they combine area growth and productivity increases. According to FAOSTAT data production increases in cereals were achieved on a land area that remained virtually the same in 30 years, confirming that productivity increases were the main source of production growth.

This section reviews a number of performance measures: yields (productivity per unit of land) of the most important food and plantation crops, labor productivity and export performance are the most important indicators.

Table 8.1 Cereal production and productivity in developing Asia (1975 and 2005)

Cereals (developing Asia)	1975	2005
Area (million ha)	299	298
Yield (kg/ha	1,814	3,428
Production (Million Mt)	542	1,023

Source: FAOSTAT data, accessed April 2006

8.2.1 Crop yields

Crop yields as an indicator of productivity have the advantage that information is easily available for a large number of years and for a wide variety of crops. As an indicator yields have a direct relation to technology. Yield as a performance measure presents productivity per ha. It does not present any information on productivity per unit of labor (man days) which expresses itself mainly in cost reductions. A problem of yield as a performance indicator is that in intensive cropping systems yields may have been pushed to long-term unsustainable levels.

Food Crops

Yield growth figures for rice and maize for the period 1975-2005 are presented in figures 8.1 and 8.2. Rice production (measured in tons of paddy) was crucial to food security and yields in developing Asia increased from 2.5 to 4.1 tons per ha – a major achievement. The most important increase was achieved in the 1975-1985 decade (the peak of the green revolution period) at 2.9% per annum, with subsequent decelerations in the growth of productivity to 1.3% and 1.0% in the two decades after 1985.

Indonesia and Sri Lanka show very similar patterns in yield development. Both were early starters in the green revolution with productivity increases of over 4% in the period 1975-1985, decelerating to less than 1% in the two subsequent decades.

The same trend of decelerating yield growth applies to all major food crops except cassava, which is also an important industrial crop. This overall slowdown in productivity growth started in the mid 1990s and has continued until 2006. While the overall trend is clear, there are some important differences between crops, countries and time periods.

Annual changes in rice production/ha presented in figure 8.1 show early productivity increases in Indonesia, due to adoption of green revolution technology, and a subsequent leveling off of productivity. The combined effects of El Niño and the political turbulence in the late 1990s caused a temporary dip in productivity, which recovered to 4.4 t/ha in 2000.

Rice productivity in Vietnam has surpassed that of Indonesia. It has shown a rapid increase from 2.1 t/ha in 1975, and now ranks with Indonesia at significantly higher levels than Pakistan and Sri Lanka. In Pakistan yields have grown from 2.3 to 3.0 t/ha over the 25-year period. In Sri Lanka yields increased from 1.9 to 3.2 t/ha.[33]

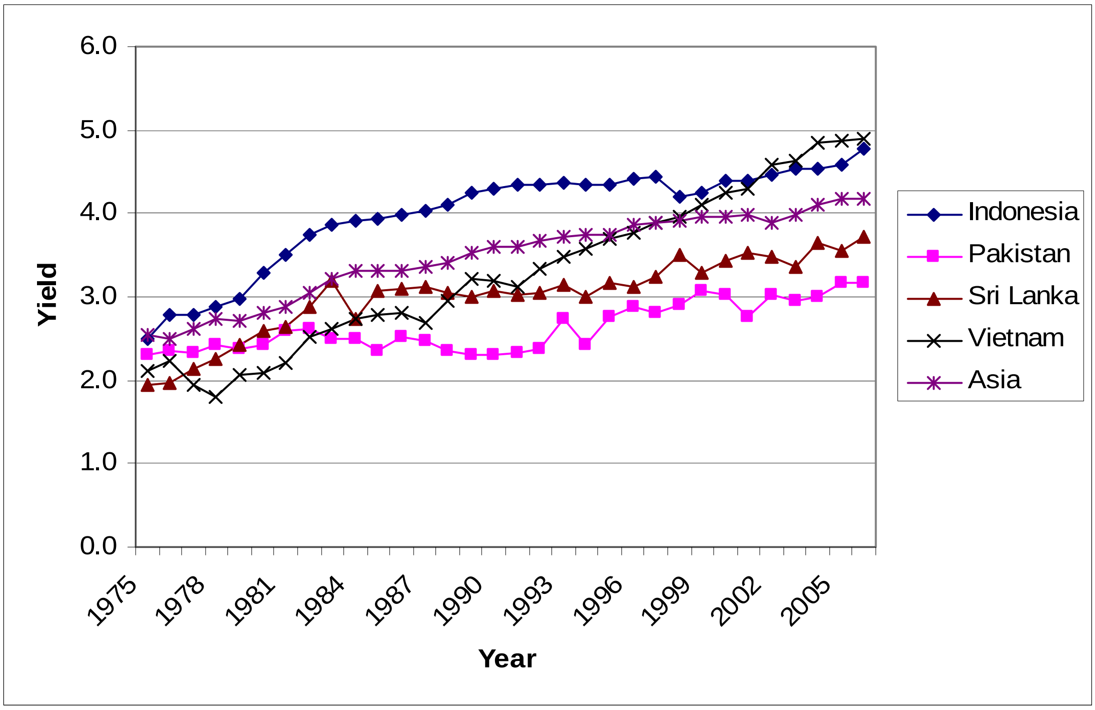
Indonesia was an early adopter of green revolution technology and experienced rice productivity increases of over 4% p.a. in the 1975-1985 period while productivity growth sharply decreased to 1.0 and 0.2 % p.a. in the two following decades. Sri Lanka shows a similar pattern of early productivity increases followed by declining growth. Vietnam

[33] The four countries now fall into two groups: Pakistan and Sri Lanka with productivity figures of around 3 t/ha and Vietnam and Indonesia with figures of over 4 t/ha. However it is the trends, not the absolute levels that should be reviewed. Pakistan, for example, continues to a grow a large area of high quality but lower yielding basmati rice. Absolute yield levels also increase when two or three crops per year can be grown with sufficient irrigation water.

experienced continuous productivity growth throughout the three decades of 2.7, 2.9 and 3.0% respectively. Pakistan's productivity growth has been more modest, reflecting amongst others the importance of traditional high quality rice such as basmati, which is less responsive to increased input use.

The long-term trend in Fig. 8.1 shows that the yield differences between the four countries have increased considerably since 1975. Indonesia and Vietnam have made more progress and have yields in the range of 4.5-5 Mt /ha, whereas Sri Lanka and Pakistan remain in the 3-3.5 Mt/ha range.

Figure 8.1 Rice yields in Mt of paddy/ha (1975-2006)

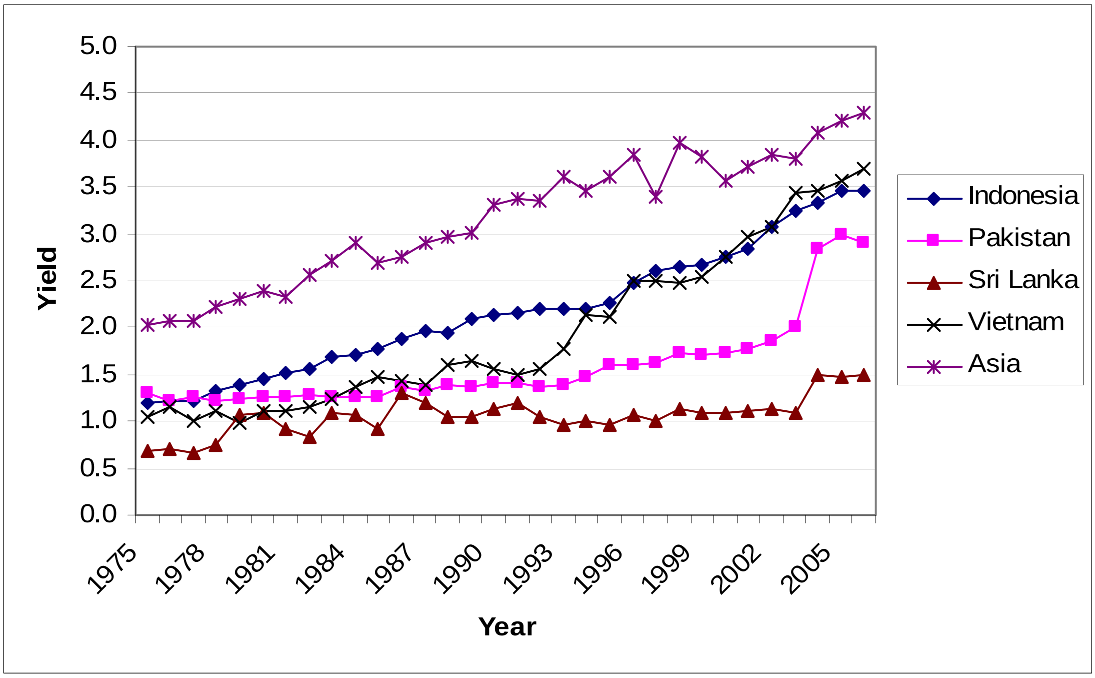


Source: FAOSTAT data, accessed June 2008

Maize productivity growth (Fig 8.2) has been even more spectacular than rice. Demand for maize in Asia is fuelled by the rapidly growing livestock industry, especially the poultry sector. For Indonesia yield growth rates were 4.1, 2.4 and 4.3 % p.a. for the three decades 1975-2005. In Vietnam the corresponding figures were 3.5, 3.6, and 5.2 % p.a. Sri Lanka figures were: 3.0, 0.6 and 4.3, while Pakistan reported increases of -0.5, 0.6 and 4.3 % p.a. Maize differs from rice in that it is not only an important commodity in public sector agricultural research, but also plays a key role in the private sector breeding industry. Hybrid maize cannot be saved as seed for next year's planting, thus providing the private sector with means to appropriate the benefits of plant breeding efforts.

Continuously increasing yield levels for maize can be explained by the fact that in the early years high yielding open pollinated varieties (OPVs) became available through public sector breeding efforts. In recent years high yielding hybrid maize varieties supplied by the private sector have gained market share rapidly in South and South East Asia. In Indonesia, for example, it is estimated that the share of hybrid maize in the total area planted to maize increased from 1.7% in 1990 to 14.3% in 1998. And of the 66 new high yielding maize varieties introduced in Indonesia between 1980 and 2001, 47 were hybrids and only 19 were OPVs (Swastika et al. 2004).

Figure 8.2 Maize yields in Mt/ha (1975-2006)



Source: FAOSTAT data, accessed June 2008

The picture in Fig. 8.2 again shows Indonesia and Vietnam as the countries with the most rapid increase in yields. Pakistan and Sri Lanka have both significantly lower yields and have experienced lower levels of yield growth (although Pakistan shows a spectacular jump from 2.00 to 2.85 t/ha from 2003 to 2004 and 2005, which is probably a statistical anomaly).

Soybean and cassava are important crops in Asia as animal feed crops, industrial crops and in a more limited way as food crops. The productivity growth pattern for soybean and cassava is more mixed and growth rates are lower than those for rice and maize. Evenson and Gollin (2003) explain this by the fact that the green revolution in wheat and maize could build on many years of research conducted in developed countries[34], while research on other crops basically started from zero.

Plantation Crops

Although no aggregate data are available, the productivity growth of plantation crops appears to have been considerably lower than for food crops. Yields for sugarcane for example have declined in many countries (China being the exception). Another traditional plantation crop, coconuts has experienced similar low or in some cases negative yield growth (Figure 8.3). Tea and coffee, which for Asia are traditional and new export crops respectively have not fared much better: productivity growth patterns have been mixed. For tea in the three most important producing countries, India, Sri Lanka and Indonesia growth rates have been -3.0, 0.7 and 0.8% p.a. respectively in the 1995 – 2005 decade. Coffee yield growth rates in Indonesia and Vietnam (where area expansion from 106,000 to 492,000 ha between 1994 and 2004 was responsible for making Vietnam the second largest producer in the world) were 0.0 and 0.9% p.a. respectively in the last decade.

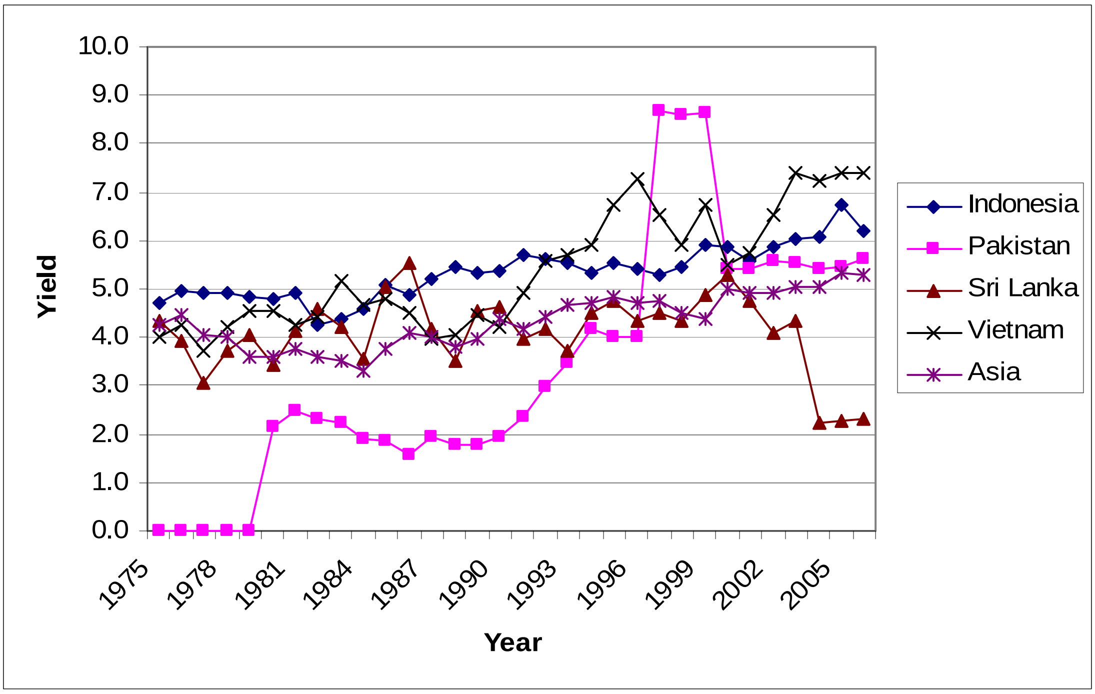
Several explanations may be offered for the limited growth in the productivity of plantation crops. First, policy attention and public research priorities since 1975 were strongly focused on food crops to ensure food security and affordable prices for growing populations. A second explanation is offered by Hayami (2000). In a long term historical account of agricultural development in Southeast Asia Hayami (2000) explains that the advantages of the plantation type of production disappear with the shift from a land-abundant agriculture to a land-scarce agriculture. The main reasons are that plantations are less efficient users of land and labor production factors than smallholder agriculture. Plantations are also overspecialized, require monitoring of agents by principals, and are often a source of class conflict. "Traditional" plantation crops such as sugar in Indonesia and tea in Sri Lanka have received little investment for many decades, and are sometimes still based on colonial time infrastructure. On the other hand, more recently established plantation crops in notably oil palm in Malaysia and in Indonesia have been very successful, at least from a production point of view.

8.2.2 Labor productivity

Changes in productivity per capita for the crops sector for the 1975-2005 period are presented in Fig. 8.4. In Sri Lanka productivity in 2005 was almost the same as in 1975 – the result of early growth and subsequent decline and stagnation. Pakistan has witnessed a steady increase from 1975 to 1995, followed by 10 years of largely stagnant productivity. Indonesia saw rapid growth from 1975 to 1996 followed by a decline as the effects of the Asian financial crisis spread throughout the economy. From 2001 onwards however labor productivity increased again by almost 20%. Vietnam shows a very similar pattern of productivity development as Indonesia. It has grown much more rapidly however from a lower base and did not stop or pause during the period of the 1997 financial crisis.

[34] In rice, high yielding varieties were made possible by crossing indica and japonica type rice, leading to the successful semi-dwarf varieties.

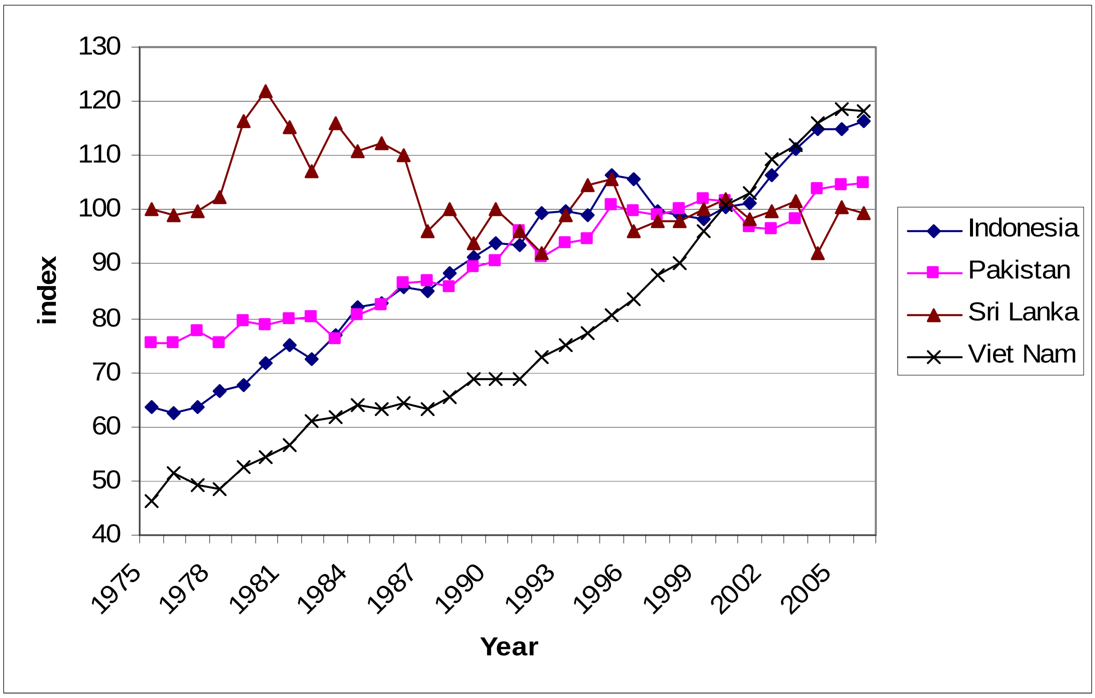
Figure 8.3 Coconut yields in Mt/ha (1975-2005)



Source: FAOSTAT data, accessed April 2006

Data on agricultural **value added per worker** provide additional information on productivity (table 8.2) and largely confirm the FAO labor productivity data. Sri Lanka started from a high base, but experienced almost no growth (0.4% p.a.) in value added since 1992-94, due to a combination of structural factors, which have made farming increasingly unprofitable (Silva et al. 1999) and security problems in rural areas and civil war in the North and East of the country. Pakistan and Indonesia experienced moderate growth rates of 1.3% p.a., while Vietnam experienced 2.7% annual growth rates, but from a very low base compared to other countries.

Figure 8.4 Per capita production indices agricultural sector (1975-2006)



Source: FAOSTAT data, accessed June 2008

Table 8.2 Agricultural value added per worker (constant 2000 US$)

	1992-1994	2002-2004	Annualized Growth rate (%)
Indonesia	498	564	1.3
Pakistan	603	688	1.3
Sri Lanka	713	743	0.4
Vietnam	225	294	2.7

Source: World Development Indicators (World Bank 2006d)

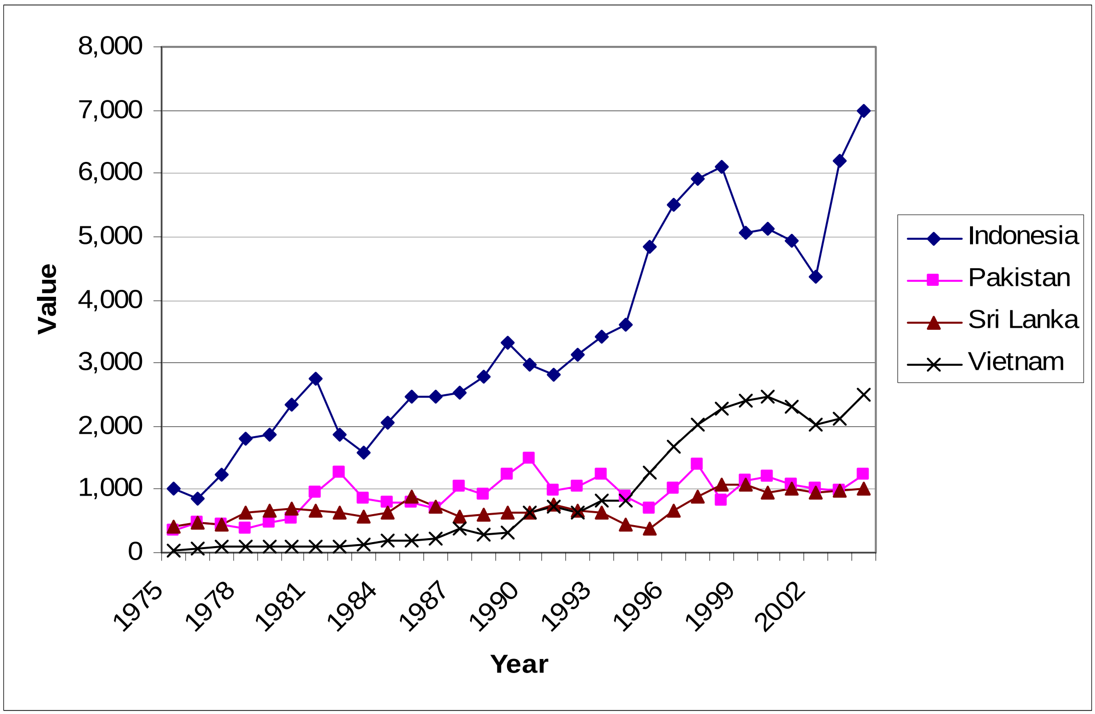
8.2.3 Agricultural exports

Export figures are frequently used as a performance indicator.[35] Agricultural exports as a performance indicator provide a basic measure of competitiveness of the sector and also reflect macro-economic factors such as exchange rates and the resulting protection rates.

Total agricultural export figures presented in Fig 8.5 are distorted by country size, but from the corresponding growth rates presented in table 8.4 it is clear that Vietnam and Indonesia have made significantly more progress than the other two countries.

[35] For example by Porter (1990) in “The Competitiveness of Nations”.

Figure 8.5 Value of agricultural exports (1975-2004) in USD



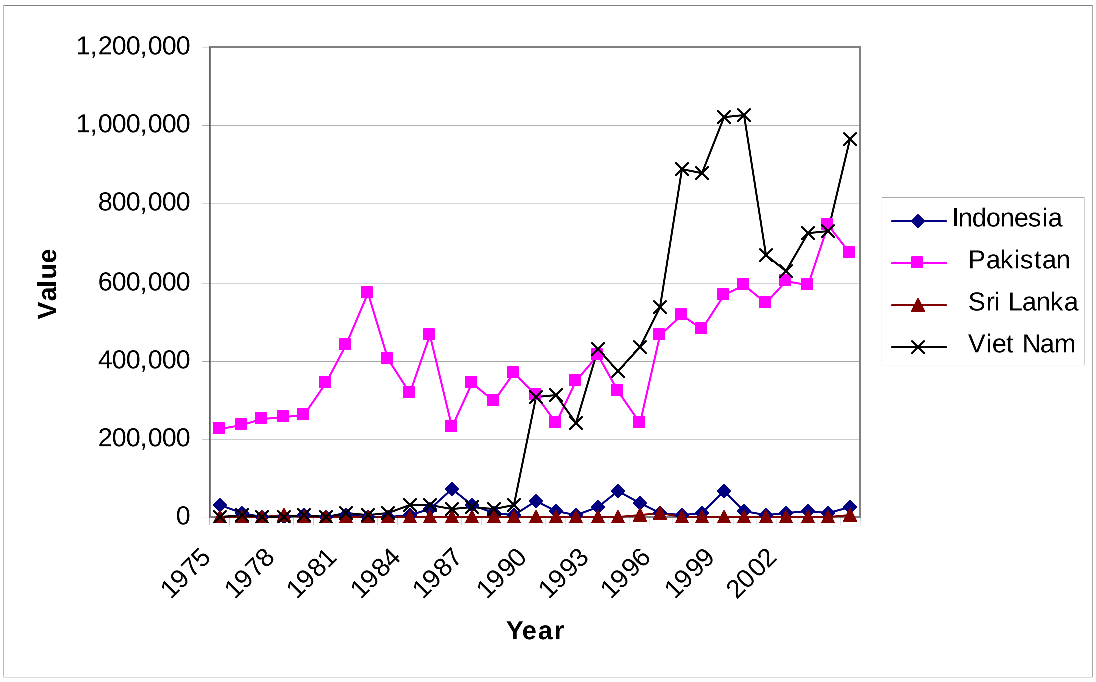
Source: FAOSTAT data, accessed April 2006

Despite fluctuations the overall pattern presented in figures 8.5 and 8.6 is very clear. Since the middle of the 1970s Indonesia and Vietnam have outperformed Sri Lanka and Pakistan consistently. In addition, the rate of increase of the two Southeast Asian countries has grown more rapidly in recent years.

Figure 8.6 presents export data on cereals, a picture that in this case is totally dominated by rice. The international rice trade market has traditionally been a very "thin" market, with only 4% of global production traded internationally. Pakistan and Vietnam have emerged as strong exporters, Vietnam as a lower-quality, high-volume producer and Pakistan mainly as an exporter of high quality basmati rice. Indonesia briefly achieved self sufficiency in the late 1980s and exported small quantities in the mid 1990s, but overall it has never been a competitive exporter. The same is true for Sri Lanka, where efficient production – the basis for competitiveness in export markets – has suffered because of rigid land tenure and agricultural production systems (Silva et al. 1999).

While cereal exports are "traditional" exports, the exports of fruits and vegetables (as perishable goods) can be classified as "modern" exports. Figure 8.7 indicates that the export performance of fruits and vegetables presents the familiar picture of early growth for Indonesia, severely interrupted for a few years during the Asian financial crises, and followed by stabilization since. Vietnam shows very steep growth without any interruption. Pakistan's exports of fruits and vegetables show a very modest increase, while exports of Sri Lanka have never really started.

Figure 8.6 Export of cereals (1975-2004), value in USD



Source: FAOSTAT data, accessed April 2006

Table 8.3 Percentage of the four major commodities in total agricultural exports, ca. 2000

Country	Percentage of 4 major export commodities	
	as part of agricultural exports	**as part of total exports**
Indonesia	55	11
Pakistan	50	10
Sri Lanka	70	21
Vietnam	19	13

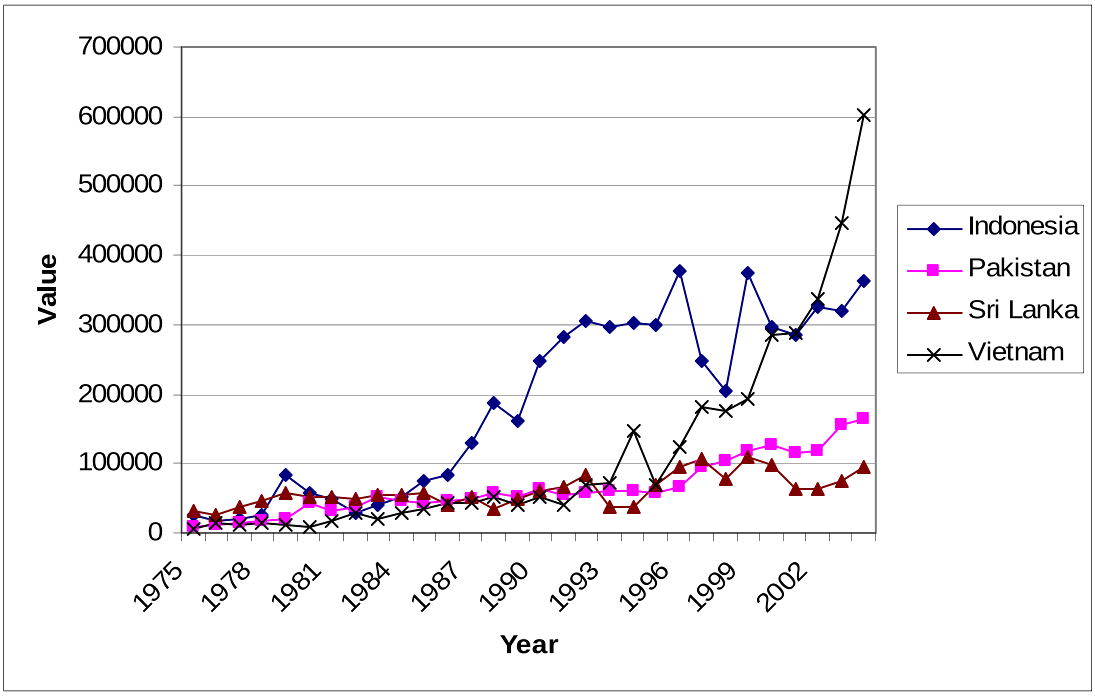
Source: FAO Statistical Yearbook 2004

8.2.4 Diversification of the agricultural sector

Most Asian countries have developed policies to diversify their agricultural economies in order to reduce their dependency on a single or a few leading commodities. The purpose of diversification policies is to improve food security, to contribute to sustainable production systems (through crop rotations), and to stabilize export earnings (Pingali 2004).

Diversification of the agricultural economy is therefore another useful indicator to measure agricultural sector performance.

Figure 8.7 Export of fruit and vegetable crops (1975-2004), value in USD



Source: FAOSTAT data, accessed June 2008

An indicator for the diversification of the agricultural economy is the percentage of the four major export commodities in the total agricultural export of a country (table 8.3). Sri Lanka has the highest dependency on a few commodities (mainly tea), Indonesia and Pakistan have more diversified exports. Interestingly, Vietnam despite being the world's second rice exporter is only for 19% dependent on four major commodities as it exports a wide range of different commodities.

8.2.5 Analysis of agricultural sector performance

The most important productivity indicators presented above graphically are summarized as growth rates from the 1975/77 period to the 2004/06 period[36]. Annual growth rates are presented in table 8.4.

[36] Most recent data for exports and productivity are for 2002/2004.

Table 8.4 Annual growth rates of selected agricultural productivity variables (1975/77 – 2004/06)

	Paddy yields	Maize Yields	Labor Productivity (per capita)	Agricultural Exports (value)	Fruit & Vegetable Exports (value)
Indonesia	1.89	3.64	2.10	6.65	9.89
Pakistan	1.01	2.94	1.10	3.58	9.20
Sri Lanka	2.06	2.73	-0.09	3.00	3.19
Vietnam	2.95	4.26	3.06	14.20	14.04

Source: FAOSTAT data, accessed June 2008

To summarize performance differences between the countries Table 8.5 presents a simple aggregation of the different agricultural sector productivity measures of the presented in the figures above (country growth rates on a scale of 1 to 4, with 4 as highest). Vietnam clearly emerges as the top performer, followed by Indonesia, Pakistan and Sri Lanka.

Table 8.5 Agricultural sector performance scores

	Paddy yields	Maize Yields	Labor Productivity (per capita)	Agricultural Exports (value)	Fruit & Vegetable Exports (value)	Total Score
Indonesia	2	3	3	3	3	14
Pakistan	1	2	2	2	2	9
Sri Lanka	3	1	1	1	1	7
Vietnam	4	4	4	4	4	20

Source: table 8.4

While there are some differences at the individual crop productivity level and between the different export indicators, it is clear that when the rankings for crop yields and for exports are aggregated, the pattern is consistently the same ranking of Vietnam, Indonesia, Pakistan and Sri Lanka.

Agricultural sector performance may be characterized based on the growth of the agricultural sector (table 8.5) and on the diversification of the agricultural economy (table 8.3).[37] A summary of results is presented in table 8.6.

[37] In addition to growth and diversification, sustainability is an important characteristic of the performance of the agricultural sector. While several analyses (e.g. Byerlee and Murgai 2001) have a attempted to assess the sustainability of production systems through total factor productivity analysis (TFP), there is no data available for the group of countries in this study.

Vietnam, despite (or perhaps as a result of) being a late starter, is the overall star performer: it tops the league in land productivity (yields), labor productivity, and exports. Vietnam's performance is broadly based on a wide variety of commodities: rice, maize, fruits and vegetables, but also coffee rubber and others). It also ranks highest in labor productivity and export growth. Vietnam has experienced continued growth since it starting opening up its economy in the mid 1980s. The government of Vietnam has overseen the process of Vietnam's integration into the world economy and continues to play a major role in the economy.

Table 8.6 Growth and diversification of the agricultural sector

	Growth of agricultural sector	Diversification of agricultural economy
Indonesia	High	Medium
Pakistan	Medium	Medium
Sri Lanka	Low	Low
Vietnam	Very high	Very high

Indonesia's performance is characterized by significant yield increases, especially in maize caused by the improved availability of private sector produced hybrid varieties. Because of the extremely high population density and limited land availability on the main island of Java, Indonesia has barely been able to keep up rice production with population growth, which explains the poor performance in cereal exports. Indonesia has, since the 1980s followed a policy of diversification of the agricultural sector, away from its dominance by rice. In some commodities (maize, cassava, oil-palm) it has been quite successful, though Indonesia's model is also vulnerable to shocks and setbacks.

Pakistan's performance is a different case: it is more narrowly based on a few successful commodities: rice, wheat and cotton. Pakistan's agricultural economy has followed a model of specialization rather than diversification. The strong performance of the sector since 1997 can be explained by the introduction in that year of policies to reduce the Government's direct influence in the overall economy with a move toward a market-led economy and a removal of distortions caused by subsidies and monopolistic practices. For agriculture a comprehensive package of incentives designed to improve production was introduced including increased support prices, credit availability, improved drainage and irrigation. Also policies were introduced promoting export-led growth and the development of agribusiness and post-production added value. The performance of the agricultural sector has improved since the introduction of reforms with a 12% increase in sector GDP since 1999/00 (Greer and Husaini Jagirdar 2006).

Sri Lanka was Asia's early top performer, but has reversed its performance on most agricultural performance indicators. Its performance has suffered from an overregulated economy and structural rigidities in markets (especially land and labor). At the same time Sri Lanka's government, unlike that of Indonesia in the 1980s and Vietnam in the 1990s, did not provide the sort of strategic leadership in getting the agricultural economy moving. The situation was further exacerbated by the civil war, which contributed significantly to the lack of investment in rural areas.

8.3 Performance of R&D and innovation systems

For developing countries not many comparative data on the performance of R&D and innovation systems are available. This includes the four countries in this study where basic data on a variety of indicators such as R&D expenditures, research staff, patents granted, and receipts of royalties and license fees are very patchy (table 8.7).

Table 8.7 Technology diffusion and creation indicators

HDI rank		**Patents granted to residents** (per million people)	**Receipts of royalties and license fees** (US$ per person)	**Research and development (R&D) expenditures** (% of GDP)	**Researchers in R&D** (per million people)
		2002	2003	1997-2002[b]	1990-2003[b]
110	Indonesia	0	..	..	..
135	Pakistan	..	0.1	0.2	88
93	Sri Lanka	0	..	..	197
108	Vietnam	0	..	..	..

Source: Human Development Report 2005

8.3.1 Technology capabilities

Archibugi and Coco (2003) have developed a composite index (ArCo) of technological capabilities at the country level, which covers both developed and developing countries, and which includes a number of variables associated with technological change. The composite index builds on the Technology Achievement Index (TAI) developed for the UNDP Human Development Report (2001) and the UNIDO Industrial Development Scoreboard. It expands the number of countries in comparison to similar performance indices to include a large number of countries (total = 162).

The ArCo index is built on three key dimensions of technological capability:
a) Technology creation[38], including:
- a1) patents
- a2) scientific articles

b) Development of human skills, including:
- b1) Internet penetration
- b2) telephone penetration
- b3) electricity consumption

[38] R&D data are not included in building the index as they are not available for all countries

c) Technological infrastructures, including:

- c1) tertiary science and engineering enrollment
- c2) mean years of schooling
- c3) literacy rate

In a comparison of the ArCo index to other multidimensional indices such as TAI the authors (Archibugi and Coco, 2004) emphasize the importance of a composite indicator that covers a large number of countries. They also indicate that there is very high correlation between the different indices, with a rank correlation of 0.98 between the ArCo and TAI indices and most other rank correlation above 0.90. Table 8.8 presents the composite ArCo index for selected countries. Growth rates between 1990 and 2000 for Indonesia and Vietnam are almost double those of Sri Lanka and Pakistan, indicating that the Southeast Asian countries are improving their performance much faster than South Asia.

The authors then divide countries in four categories, based on their position in the scale: leaders (1-25), potential leaders (26-50), latecomers (51-111) and marginalized countries (112-162)[39]. Looking at the rankings the picture changes, with differences between Sri Lanka and Pakistan at positions 95 and 120, and Indonesia and Vietnam in intermediate positions. The ranking and the differences in position can be explained through a more detailed look at the disaggregated data that constitute the index and which are available at the author's website: www.danielearchibugi.org.

Table 8.8 Composite ArCo technology capabilities index.

Country	2000 ArCo Technology Index	1990 ArCo Technology Index	2000 ranking	1990 ranking	Growth rate 1990-2000 (%)
Sri Lanka	0.28	0.23	95	96	23.0
Indonesia	0.27	0.19	100	108	39.7
Vietnam	0.24	0.16	107	118	45.5
Pakistan	0.19	0.16	120	121	20.9

Source: Archibugi and Coco 2003

Table 8.9 presents the three sub-indices that constitute the ArCo index. In international perspective, all four countries display very weak positions on the technology creation index[40] (patents and scientific articles) and the growth rates have to be read with care. Nevertheless the weakening position of Sri Lanka (which was the most advanced country in Asia after Japan from the 1950s to the 1970s) can be clearly seen. Strong growth is shown by Indonesia and Vietnam, the latter from a very low basis. With regard to the technology infrastructure sub-index it is interesting that the four countries had reached similar levels of performance in 2000, with Vietnam's rapid growth from 1990 as the most remarkable characteristic.

[39] In another section the authors include technology imports as an indicator, but as this reduces the number of countries in the analysis to 86 and does not include Vietnam, this version of the indicator is not presented here.
[40] Sweden, the number one performing country had scores of 0.67 and 0.79 in the two years

Table 8.9 Sub-indices of the ArCo technology capabilities index, four countries

ArCo sub-indices	1990	2000	Growth rate
Technology creation index			
Indonesia	0.000	0.000	52.9%
Pakistan	0.001	0.001	-4.7%
Sri Lanka	0.003	0.002	-36.5%
Vietnam	0.000	0.001	51.7%
Technology infrastructures			
Indonesia	0.189	0.338	79.1%
Pakistan	0.240	0.314	30.8%
Sri Lanka	0.205	0.331	61.3%
Vietnam	0.097	0.303	212.4%
Human skills			
Indonesia	0.381	0.457	20.2%
Pakistan	0.233	0.258	10.9%
Sri Lanka	0.474	0.506	6.8%
Vietnam	0.396	0.414	4.6%

Source:
http://www.danielearchibugi.org/downloads/papers/Theory_Measurement_Techn_Change/ArCo_Index.xls, accessed May 2006

The human skills index shows one reason why Pakistan's performance trails that of the other countries in the overall composite index: it scores significantly lower than the other three countries on the skills indicator. To a large extent this is caused by Pakistan's severe underperformance in education levels. Similarly, Sri Lanka's high performance in the index is explained by its traditionally high levels of education.

8.3.2 High-tech exports

High-tech exports as a share of manufactured exports provides another indicator of the state of a country's innovation system, although it is also an imperfect indicator – especially for agricultural innovation which is usually not included in the high tech sector. Much of the high-tech exports are based on assembly type of operations, often in export zones and with little impact on the national innovation system. Still, it is surprising that a country such as Sri Lanka with a highly skilled English speaking labor force, and with important export processing zones for the textile industry, has only a very low proportion of its exports in the high-tech sector. Table 8.10 presents the high-tech exports as a percentage of total manufactured exports and shows that the scores of Sri Lanka and Pakistan (with 1.5 and 1.3% respectively) contrast remarkably with the figures for Indonesia (16%) and Vietnam (5%).

8.3.3 Analysis of innovation system performance

The limited data available of the performance of the innovation system still permit some conclusions. With regard to the technology capabilities index, overall the four countries are not very far apart, with scores ranging from 0.19 for Pakistan to 0.28 for Sri Lanka. What is remarkable though are the difference in growth rates with Indonesia and Vietnam experiencing increases of around 40%, while Sri Lanka and Pakistan experienced growth of around 20%. In other words, the two South Asian countries are not keeping up with Indonesia and Vietnam.

This picture is confirmed when looking at the sub-indices, especially at the technology creation index. Although the numbers are small, and margins of error therefore large, it is still striking to see that both Indonesia and Vietnam have experienced growth rates of over 50%, while Sri Lanka and Pakistan have experienced negative growth rates. Noteworthy are also the differences in growth figures of technology infrastructures: here Vietnam has shown an increase of over 200%, which reflects a very large public investment effort in comparison with Indonesia and Sri Lanka (growth rates in the range of 60-80%) and Pakistan with 30%.

Table 8.10 High-technology exports as a % of manufactured exports

	2000	2001	2002	2003	2004	Average 2000 – 2003/4
Indonesia	16.16	13.96	16.38	14.46	16.13	15.4
Pakistan	0.59	0.36	0.78	1.35	1.32	0.9
Sri Lanka	..	2.3	0.73	0.67	1.49	1.3
Vietnam	11.03	8.33	5.89	5.55	..	7.7

Source: World Development Indicators, accessed August 2006

The analysis of high-tech exports confirms the differences between the two South Asian countries where they are insignificant, and Indonesia where they important, and Vietnam where they are moderately important.

In summary, table 8.11 presents a ranking of countries based on their innovation system performance, showing that Indonesia is the most highly achieving country on a range of innovation indicators followed by Vietnam, Pakistan and Sri Lanka. This picture reflects early investment in R&D and innovation in Indonesia and late but rapidly increasing investments in Vietnam, while Sri Lanka and Pakistan show a pattern of stagnation.

Table 8.11 Summary innovation system indicator growth rates

	Technology Creation (ARCO)	Technology Infrastructures (ARCO)	Human skills (ARCO)	High Tech Exports	Total Score
Indonesia	4	3	4	4	15
Pakistan	2	1	3	1	7
Sri Lanka	1	2	2	2	7
Vietnam	3	4	1	3	11

Source: tables 8.9 and 8.10

8.4 Putting agricultural performance in perspective

To what extent is the performance of the agricultural systems of innovation and production[41] in line with some of the main characteristics and dynamics of the countries' socio-economic systems? And what are the key questions for more in-depth analysis? The following sections address both issues.

8.4.1 Dynamics of society and economy

This section presents a few key characteristics of the performance of the economies of the four countries to set the stage for a more in-depth analysis of the performance of the agricultural sector and the agricultural innovation system. This overview covers three dimensions: economic growth, human development, governance and policy.

With regard to economic development as expressed in the GDP per capita growth it can be observed that all four countries have made significant progress as indicated in table 8.12 and figure 8.8.

Annual growth rates for the period have been remarkably steady over the years with the exception of Indonesia's performance during the 1998-1999 Asia financial crisis when Indonesia's per capita GDP dropped by 12%. On a long-term basis the performance of Sri Lanka and Indonesia is quite similar. Vietnam has experienced spectacular growth, starting from the mid 1980s. Pakistan's growth has been slower than that of other countries.

A similar pattern is shown in the data in UNDP's Human Development Index (HDI) presented in table 8.13. Sri Lanka with its long history of high levels of education has consistently been in the lead. Vietnam's score is growing at a faster pace than Indonesia's and Pakistan has the lowest performance.

Table 8.12 GDP per capita and compound annual growth rate (1980 – 2005)

Country		GDP per capita (PPP dollars)	Growth rate
	1980	**2005**	**1980-2005 (% p.a.)**
Indonesia	1003	4458	6.1
Pakistan	704	2628	5.4
Sri Lanka	933	4384	6.4
Vietnam	430	3025	8.1

Source: International Monetary Fund, World Economic Outlook Database, April 2006

[41] The term "system of innovation and production" was introduced by Malerba (2002) in a review of sectoral system of innovation and production.

Table 8.13 Human Development Index (1980-2003)

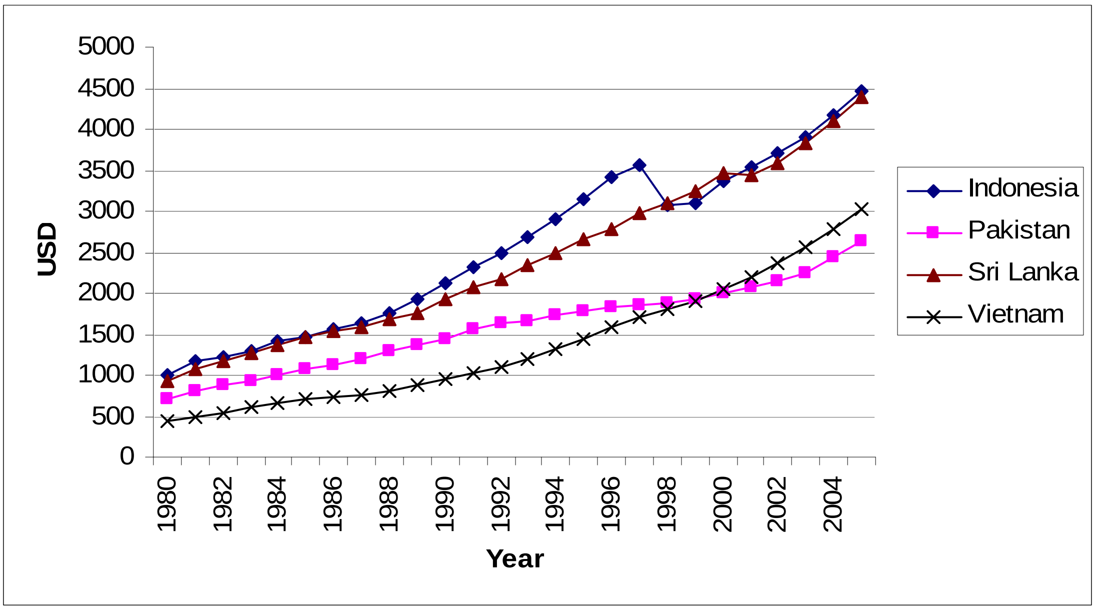
	1980	**1985**	**1990**	**1995**	**2000**	**2003**
Indonesia	0.53	0.583	0.625	0.663	0.680	0.697
Pakistan	0.386	0.419	0.462	0.492	…	0.527
Sri Lanka	0.649	0.681	0.705	0.727	…	0.751
Vietnam			0.617	0.660	0.695	0.704

Source: Human Development Report 2005

Table 8.14 presents a summary of the governance indicators developed by Kaufmann et al. at the World Bank. Data are available for 1996, 1998, 2000, 2002, and 2004. The table presents the averages for the period. Sri Lanka presents high scores on all but one of the indicators, which is political stability. Between 1996 and 2004 little change can be observed for the Sri Lanka governance indicators with the exception of Rule of Law indicator which shows a small decline. Indonesia shows high scores on Government effectiveness and Regulatory quality and a low score on political stability. Since 1996 Indonesia's score on Voice and accountability has significantly increased, while during the same period Government effectiveness has decreased sharply from 70 – 40 in the percentile rank scores. Vietnam shows high scores on political stability and government effectiveness, and very low scores on Voice and accountability. Finally, Pakistan has on average low scores, several of which have declined over the 1996-2004 period.

Two things stand out from the table: the high scores for Vietnam on government effectiveness and political stability, and the high scores for Sri Lanka on the other indicators: voice and accountability, corruption control, and rule of law. In some ways Vietnam and Sri Lanka are opposites: the former with no democracy, but an effective government and political stability; the latter with all the democratic institutions, but mostly lacking political stability.

Figure 8.8 GDP per capita in USD based on PPP, 1990-2005



Source: International Monetary Fund, World Economic Outlook Database, June 2007

Table 8.14 Governance indicators – percentile rank scores (average 1996 – 2004)

	Indonesia	Pakistan	Sri Lanka	Vietnam
Voice and accountability	26.2	17.6	42.1	8.1
Political stability	12.3	14.8	10.1	61.2
Government effectiveness	41.6	31.8	46.3	48.1
Regulatory quality	41.2	25.1	64.3	24.8
Rule of law	21.7	30.2	57.4	31.6
Corruption control	16.2	20.1	54.1	29.8
Average	26.5	23.3	45.7	33.9

Source: Based on Kaufmann et al. (2005)

The World Bank also prepares a ranking of the economic policies of its recipient countries. In 2006 this ranking was made available for the first time on the World Bank website (The Economist 2006). The country performance rating is based on metrics and on staff assessments and is presented in table 8.15. As it is partly based on the Governance indicators presented above, it is not surprising that the economic policy ranking is quite similar to the governance ranking.

Table 8.15 Economic policy ranking 2005

	IDA Country Performance Rating
Indonesia	3.06
Pakistan	2.95
Sri Lanka	3.79
Vietnam	3.76

Source: World Bank 2006e.

8.4.2 Observations and questions

There are some remarkable differences between country agricultural performance and overall economic and governance performance. Indonesia and Vietnam have witnessed strong GDP growth and strong agricultural sector growth. Sri Lanka and Pakistan have combined strong overall GDP growth with more limited growth in agricultural sector performance.

It is also worth noting that in the "Governance Matters" ratings of the World Bank (Kaufmann et al. 2005), Sri Lanka consistently receives the highest score of the four countries studied for a number of indicators such as government effectiveness, regulatory quality, and corruption control. These high ratings are not reflected in Sri Lanka's overall economic performance and seem to be especially at odds with Sri Lanka's low agricultural performance. This could mean several things: that the Governance Matters indicators measure something different (e.g. the quality of the legal framework is high on paper, but not in reality), that governance does not matter as much as Kaufmann et al. state, or that agriculture is a special case when it comes to performance.

The differences between the agricultural performance of the different countries cannot easily be explained as a reflection of differences in overall economic development. The performance differences suggest a number of questions that will be explored in more depth in the following chapters. These include the performance of drivers and paradigms in the four countries (chapter 9), the roles of public and private actors in innovation (chapters 10 and 11), and the emergence of innovation networks (chapter 12).

9. Innovation drivers and paradigms in four Asian countries

9.1 Introduction

This chapter analyzes how different countries perform in relation to drivers and paradigms. What are relationships between the four innovation paradigms and the key drivers of innovation: internationalization, technical and institutional change? How do the innovation drivers manifest themselves in the four countries reviewed in this study? And how do these countries perform in relation to the four paradigms?

Internationalization affects innovation directly as it brings new actors into domestic innovation arenas in Asian countries and it works indirectly as it affects technical and institutional change processes. Institutional change can come from outside the country – often in the form of an adaptation to pressures from abroad – or it can be a domestic development. Similarly, technical change can take place through international technology transfer, or it can be home-grown.

Section 9.2 presents a discussion of the innovation drivers in relation to each of the four paradigms. Section 9.3 discusses how internationalization, technological and institutional change present themselves in the four countries. Section 9.4 presents concluding remarks on the performance of the different countries in relation to the four paradigms.

9.2 Drivers and paradigms

9.2.1 Internationalization and the four paradigms

Internationalization is a pervasive process that affects each of the paradigms in different ways.

Internationalization and the green revolution
Key international actors in the green revolution were donors and charitable organizations (such as the Ford and Rockefeller foundations) providing funding for a network of International Agricultural Research Centers (IARCs). Governance of this group of donors, research centers and developing country recipients is organized through the Consultative Group on International Agricultural Research (CGIAR), the Secretariat of which is provided by the World Bank. The chairman of the CGIAR is a Vice-President in the World Bank.

The CGIAR was generally seen as very effective both by its supporters and its detractors. In 1998, the (sympathetic) third CGIAR System Review concluded that: “Investment in the CGIAR has been the most effective use of official development assistance (ODA), bar none”.[42] Criticism of the CGIAR has focused on a number of topics (some reflecting the criticism of the green revolution as discussed in chapter 9). An important critique has been

[42] CGIAR System Review Secretariat, 1998 p. 1

directed at the CGIAR's informal network nature and specifically the fact that this informal network of research centers holds, in its gene banks, an important share of the world's genetic resources. The ownership of, and access to these resources is becoming increasingly important with the privatization of genetic technology under the biotechnology paradigm. After lengthy negotiations formal governance of the genetic resources held in trust by the CGIAR was transferred to FAO, which as an intergovernmental body, is seen as more legitimate governor of genetic resources than the private club of IARCs.

While the core of the green revolution – the development of modern varieties – was mainly a public matter, the private sector has played a role especially through the production of agrochemicals, machinery, and hybrid seeds for a limited range of crops of which maize and horticultural crops are the most important. The logic for the private sector to focus on hybrid seeds is that these cannot be replanted without rapid loss of productivity.

Internationalization and the sustainability paradigm

The international dimension of the sustainability paradigm is partly linked to IARC researchers who initially operated outside of the mainstream of the green revolution paradigm. These researchers often found a place in farming systems departments and social science programs. In some cases "dissident" researchers had to leave CGIAR Centers – Peter Kenmore, the father of the Integrated Pest Management School (Kenmore 1991) left IRRI to find a new home at FAO. Internationally, the sustainability paradigm has also taken root in academia worldwide and university researchers have played a prominent role in networks of researchers (Röling and Wagemakers 1998). International consultancies specializing in sustainable development and often linked to universities have become well established. Donors, who discovered the poverty alleviation agenda years ahead of the CGIAR system, have successfully tried to influence the CGIAR research agenda in the direction of participatory and sustainable development by sponsoring special programs. Finally, as sustainable development is receiving ever more attention, a number of leading multinational agri-food companies have established their own Sustainable Agriculture Initiative (SAI)[43]. SAI counts 21 members and includes European food multinationals such as Unilever, Nestlé and Danone and US companies such Coca-Cola, McDonalds and Kraft. SAI aims to develop sustainable agricultural practices "…harmonised along the food chain" (Saiplatform 2007). SAI focuses on knowledge building, awareness raising, stakeholder involvement and implementation of sustainable practices in a number of important commodities: cereals, coffee, dairy, palm oil, potatoes and vegetables.

Internationalization and the biotechnology paradigm

The international actors in the gene revolution are first and foremost the international life sciences MNEs of which Monsanto has become the most active and well known. Second, on a much smaller scale, a number of international public biotechnology programs involve universities and public research institutes and work together with CGIAR and national programs in developing countries. Their activities are often aimed at building capacity for

[43] http://www.saiplatform.org/

developing countries to reap the benefits of the biotechnology or to assess and manage risks related to biotechnology (e.g. biosafety).

A number of private initiatives to promote access to biotechnology have also taken off, often with some form of public support. Examples are CAMBIA (Center for the Application of Molecular Biotechnology in Agriculture) an Australian initiative, which takes an "open source" approach to biotechnology, making available as widely as possible the biotechnologies that are in the public domain. CAMBIA also provides information and assistance on issues relating to intellectual property. USAID, the United States aid agency, has supported a number of programs to promote the application of biotechnologies in developing countries. The Agricultural Biotechnology Support Project (ABSP) managed by the Institute of International Agriculture at Michigan State University from 1991-2003[44], and the Program for Biosafety Systems (PBS) managed by the International Food Policy Research Institute[45], since 2003 are examples. In the Netherlands, the Directorate General International Cooperation of the Ministry of Foreign Affairs operated a Special Program Biotechnology and Development with activities in Colombia, India, Zimbabwe and Kenya.

Internationalization and the agri-food chain paradigm

The supermarket revolution is obviously driven by the big international food retailers. International food chains are becoming the dominant model of private sector led innovation. A key driver for supermarkets to expand to developing countries is that home markets in the US, EU and Japan are saturated and show little growth potential. The internationalization process is facilitated by national and international market liberalization and supporting technologies from the fields of logistics, chain management, and ICT.

A key governance mechanism in international agri-food chains is provided by private standards such as EurepGAP[46], an initiative of European supermarkets to promote good agricultural practices (GAP). With regard to the supermarket revolution in developing countries the agri-food chain paradigm is benefiting from general liberalization policies in many developing countries and specifically from domestic regulatory changes in developing countries towards the retail sector, which is opening markets to international supermarket chains. As a result international supermarket chains have rapidly expanded their market share of fresh products and dry goods in many developing countries. This development started in capital cities and with wealthy customers, but increasingly supermarkets are expanding to second tier cities and catering to the needs of the "bottom of the pyramid" (Prahalad 2005).

9.2.2 Technical change and the four paradigms

The four paradigms have different and competing views on the nature of the innovation process and on the key technologies that contribute to performance.

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[44] http://www.iia.msu.edu/absp/
[45] http://www.ifpri.org/themes/pbs/pbs.htm
[46] EurepGAP is a scheme initiated by European supermarkets to promote Good Agricultural Practices (GAP) http://www.eurepgap.org

Technical change and the green revolution

The green revolution constituted a systemic innovation based on fundamental changes in plant architecture. Shorter, stronger stems helped prevent rice plants from lodging and at the same time helped to produce more grain and less straw. It was soon realized that the new rice plants would only do the trick of increasing yields with the right amounts of water and fertilizer. As the agrochemicals needed to be applied in a specific dosage, in a specific manner and at a specific time, the seed-fertilizer package needed to be complemented with improvements in crop management practices. The cropping systems and farming systems approaches were the response to the need to integrate seed, fertilizer, pesticides, land and labor in a coherent manner. Private seed companies have contributed to the green revolution through the development and dissemination of hybrid seeds for a limited range of crops.

Technical change and the Sustainability Paradigm

Whereas the green revolution started as a global project which only slowly and sometimes reluctantly incorporated local adaptations (as it became apparent that more was needed than just new seeds and fertilizer), the sustainability paradigm started off with local initiatives. Sometimes these focused on adapting generic new technologies to local production situations (domains). In other cases, notably in the "indigenous knowledge" model, the sustainability movement sought to preserve and enhance traditional technologies and practices. Examples are the use of traditional crop rotations to maintain soil fertility[47] and traditional methods for dealing with pests and diseases. Technological change plays a limited role in the sustainability approach. Sometimes new technology is rejected because it is seen as the main cause of unsustainable practices, while in other cases new technology is welcomed as long as it contributes to sustainable development. The LEISA (Low External Input Sustainable Agriculture) approach to agricultural innovation aims to reduce farmer dependency on modern inputs through the design of extensive, often low-productivity cropping systems[48].

Technical change and the biotechnology paradigm

The nature of technical change in the biotechnology paradigm leads to radical innovations, based on fundamentally new genetic technology. At present the biotech revolution has taken off mainly in a few developing countries (Brazil and Argentina for soybeans and China for cotton). Most other countries have kept a tight regulatory lid on the on research and dissemination of agri-biotech innovations. Nevertheless, the area under transgenic crops in developing countries is growing rapidly (ISAAA 2006, Business Week 2007). Biotechnology will become more pervasive in the near future for another reason: researchers are increasingly applying the techniques of genetic modification in such a way that the final product does not contain or express genes from other organisms (COGEM 2006). Using this approach researchers and life science companies hope to bypass the tight regulatory framework in place for transgenic crops in many countries.

[47] Traditional practices can be very unsustainable as well – for example land preparation in slash and burn agriculture.

[48] http://www.leisa.info/

Technical change and the agri-food chain paradigm

Unlike in the biotechnology paradigm technical change in the agri-food chain paradigm is not built on radical new scientific breakthroughs. What is radically new about the agri-food chain paradigm is that it combines in novel ways developments in ICT, supply chain management, reduced transport cost, increasing availability of cold storage, new international standards on product quality and safety and new government retail policies in many countries.

Technical change in this paradigm is not only a question of dissemination of best practices to all producers and traders participating in a particular agri-food chain – "upgrading" being the key strategy – it involves considerable tacit know-how as well. Supermarkets and their customers expect constant product quality throughout the year, regardless of production region, weather conditions and other conditions that may affect quality. This requires a high level of standardization of production practices: varieties, types of pesticides, quantities and timing of application, harvesting and storage and packing practices are all strictly prescribed in production standards and protocols. These are discussed in more detail under "institutional innovation" below.

9.2.3 Institutional change and the four paradigms

Openness to institutions is important for countries to benefit from globalization. Openness to international institutions allows for institutional innovation, can introduce transparency, and promote rule-bound behavior in policy areas where discretion and rent-seeking are common (Rodrik 1999). But imported institutions may also be inappropriate for developing countries – think of "northern" standards and norms for IPR, food standards, and possibly child labor.

As discussed earlier, institutional theory sees organizations as the players, and institutions as "rules of the game": these are the mechanisms that govern the interaction between organizations. This section discusses four types of institutional arrangements or ways in which institutions manifest themselves. They are: policies, (related to objectives), the legal and regulatory framework that provides the context for interaction between actors, coordination mechanisms that govern interaction and exchange mechanisms that specify the choice of instruments for the interaction between organizations. The dominant institutional arrangements vary markedly between the four paradigms. Table 9.1 presents an overview and examples of which institutions are typical for each of the paradigms.

Institutional change and the green revolution

At the policy level the green revolution was completely determined by the objective of achieving national level food security, which manifested itself in policies to create the basic infrastructure (irrigation and drainage), to ensure the availability of inputs (such as seed and fertilizer) and to subsidize their cost to ensure wide availability to producers. The green revolution was mainly public in nature and intellectual property did not play an important role. Seed quality was of key importance and many countries established public varietal release and seed certification procedures and agencies to implement seed policies and to provide recommendations on the use of specific varieties. The actual nature of the seed certification process differs between countries and depends on the role of the public sector in agriculture[49]. Many countries in Asia have created national fertilizer commissions with the task to ensure quality and to provide recommendations for effective application, but with liberalization the role of these public institutions is declining. Coordination in the agricultural innovation system under the green revolution paradigm is public in nature and follows a strong hierarchical model. The key exchange mechanism is a one-way, top down system of technology transfer as exemplified in the Training and Visit (T&V) model of agricultural extension that has long been promoted in many World Bank funded agricultural and rural development projects (Anderson et al. 2006).

Institutional change and the sustainability paradigm

The sustainability paradigm differs in many ways from the green revolution. Basic policy objectives are related to rural development, addressing environmental problems and the alleviation of poverty. As a bottom-up process the regulatory framework is light and consists of informal or formal agreements, memoranda of understanding, and public-private partnerships or consortia. Coordination is through network types of mechanisms involving producer organizations, NGOs, and sometimes private and public sector bodies. Innovation in the sustainability paradigm has a strong emphasis on learning as opposed to the technology transfer model that is dominant in the green revolution paradigm. In many countries learning about agricultural innovation has been institutionalized in the model of farmer field schools (Loevinsohn et al. 1998).

Table 9.1 Institutional arrangements and paradigms

Paradigms	Green Revolution	Sustainability	Biotechnology	Agri-chain
Institutional arrangements				
Policies	Infrastructure provision Subsidized inputs Food security	Rural development Environment Poverty alleviation	S&T subsidies, tax credits for R&D	Export promotion Upgrading local production
Regulatory Framework	Varietal release Seed certification	Public-private partnerships MoU's Codes of conduct	IPR: patents, Plant breeders rights Biosafety	International trade agreements Retail laws (local supers)
Coordination mechanisms	Hierarchy/Public	Civil Society networks Codes of conduct	Hierarchy/private	Market Standards, Contracts EurepGAP
Exchange mechanisms	Technology transfer	Learning	MTAs, contracts	Credit, production plans, inputs Supply chain management

[49] In most countries informal seed systems continued to play a major role alongside the formal public systems.

Institutional change and the biotechnology paradigm

The biotechnology paradigm is driven by policies to promote Science and Technology and by policies to promote high-tech innovation. Government policy instruments include funding of science and technology and providing incentives to companies that conduct R&D in the form of tax credits or other subsidies. The biotech revolution has developed a strong regulatory framework, mainly focused on issues of property (IPR) and (bio) safety. A key exchange mechanism in the biotech paradigm is the Material Transfer Agreement (MTA) which is a contract that governs the transfer of tangible research materials (cell lines, antibodies, etc).between two organizations, often universities and companies. The content of the MTA is specific to the nature of the material, its intended use and the types of organizations involved (UC Berkeley, 2006). Empirical evidence as to whether MTAs facilitate or constrain collaboration is mixed (Rodriguez et al. 2006).

Institutional change and the agri-food chain paradigm

Policy objectives for the agri-food chain paradigm are aimed both at external and internal markets. Export promotion is an important objective and participation in international food chains provides an incentive to upgrade local production to international standards. Key policy instruments are international trade and investment agreements. But domestic markets become increasingly important as incomes in many Asian countries grow, the population becomes more urbanized and dietary patterns change. At the national level the supermarket revolution has benefited to a great extent from changes in retail laws that allowed international supermarket chains to set up shop in Asian countries (AT Kearny 2006). The key coordination mechanism is the integrated supply chain that builds on supply chain management knowledge and know-how, on ICT, on contract farming and certified standards. Exchange mechanisms include production plans, advisory services, supplies of inputs (seed, planting material, day-old chicks, fertilizers and pesticides), and credit.

A key international institution in this respect is EurepGAP, an initiative to advance Good Agricultural Practices (GAP) set up by a large number of European supermarkets and retailers to promote food quality and food safety throughout the chain (Schneider and Gay 2006). The EurepGAP initiative fits a trend to turn over responsibilities to the private sector for a number of responsibilities that were earlier considered to be part of the public domain, including animal health and food safety. EurepGAP started as a European initiative, but for a number of agricultural sectors (e.g. fruits and vegetables) it is rapidly becoming the global standard[50]. In 2006 some 50,000 farmers worldwide were certified under EurepGAP, or one of the food quality assurance schemes that is benchmarked against EurepGAP. While still predominantly European, EurepGAP is rapidly expanding globally. In Africa KenyaGAP and GhanaGAP have been set up (as public-private partnerships, with government support) to adapt the EurepGAP standards to local situations.

Similar initiatives have not yet materialized in Asia, where EurepGAP has had limited success. Participation in EurepGAP can be measured in three ways: membership, number of EurepGAP certifiers, and number of projects. At the beginning of 2007 in Asia only one

[50] EurepGAP covers Quality Assurance Schemes in the following areas: fruits and vegetables, flowers and ornamentals, integrated farm assurance, and coffee.

Japanese organization was a member. There are neither certifiers, nor approved schemes in South or in Southeast Asia. Tam et al (2005) report on the introduction of good agricultural practices scheme, benchmarked against EurepGAP in Vietnam. EurepGAP has been introduced in Vietnam since 2000 by "…various foreigner driven projects with the technical assistance from government bodies and a few private companies" (Tam et al. 2005). The limited success of a benchmarked scheme for dragon fruit is attributed to the difference between national and international (EurepGAP) standards, lack of willingness to cooperate, lack of human resources and the high investment costs required to comply with EurepGAP standards.

9.3 innovation drivers and countries

9.3.1 Internationalization in four Asian countries

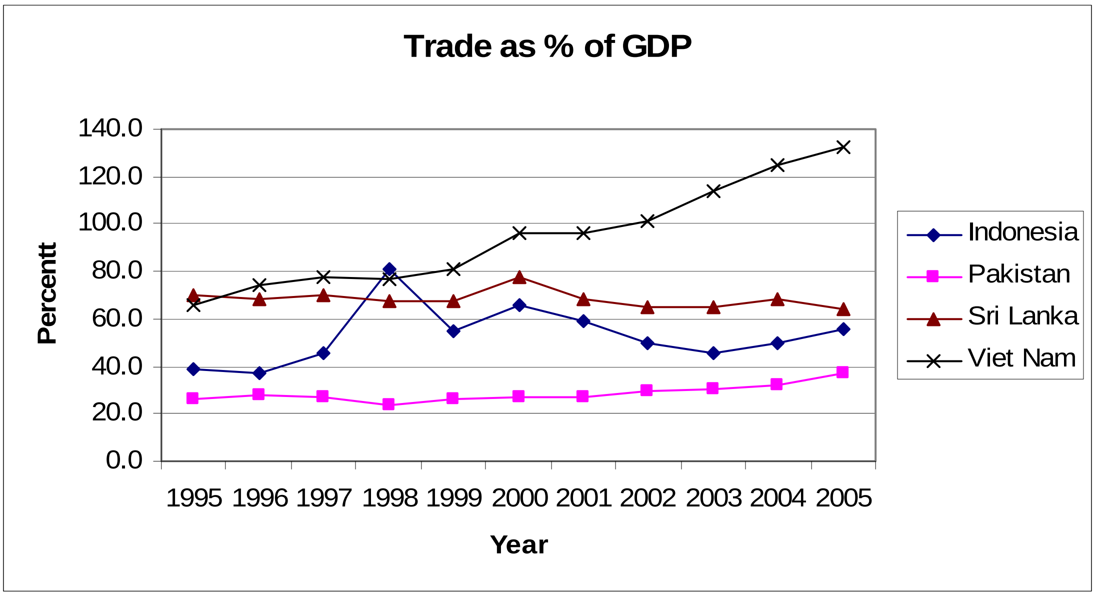
Internationalization can be measured by looking at trade patterns, foreign direct investment (both overall and for the agricultural sector), country participation in international organizations and agreements.

Taking a look at international trade patterns important differences between the four countries can be observed. Figure 9.1 presents total trade (sum of exports and imports) as a percentage of total GDP. It is clear that Vietnam's trade has grown explosively since 1995. Pakistan, on this measure has the most closed economy, though its trade has grown from 26 to 37% of GDP between 1995 and 2005. Sri Lanka's international trade has grown from 40 to 60% of GDP over the same period. This appears to be relatively open, but considering that Sri Lanka is by far the smallest economy of the four and that, in general, small economies are far more open than large economies, Sri Lanka's economy is less open than it appears. It is also the only one that is actually trading less at the end of the 10-year period than at the beginning.

Figure 9.2 presents another measure of country openness based on FDI. FDI stocks rather than annual flows are presented, as the latter are much more volatile. Figure 9.2 presents the sum of inward and outward FDI stocks, but in all countries outward FDI is tiny compared to inward FDI (and in the case of Vietnam outward FDI is not recorded separately). Again Vietnam emerges as the fastest grower with the highest performance. The other three countries' performance is very similar with very little growth between 1995 and 2005 and FDI at about 10% of GDP. The spike in the figure for Indonesia in 1998 can be explained by the sharp fall in GDP in that year as a result of the Asian financial crisis.

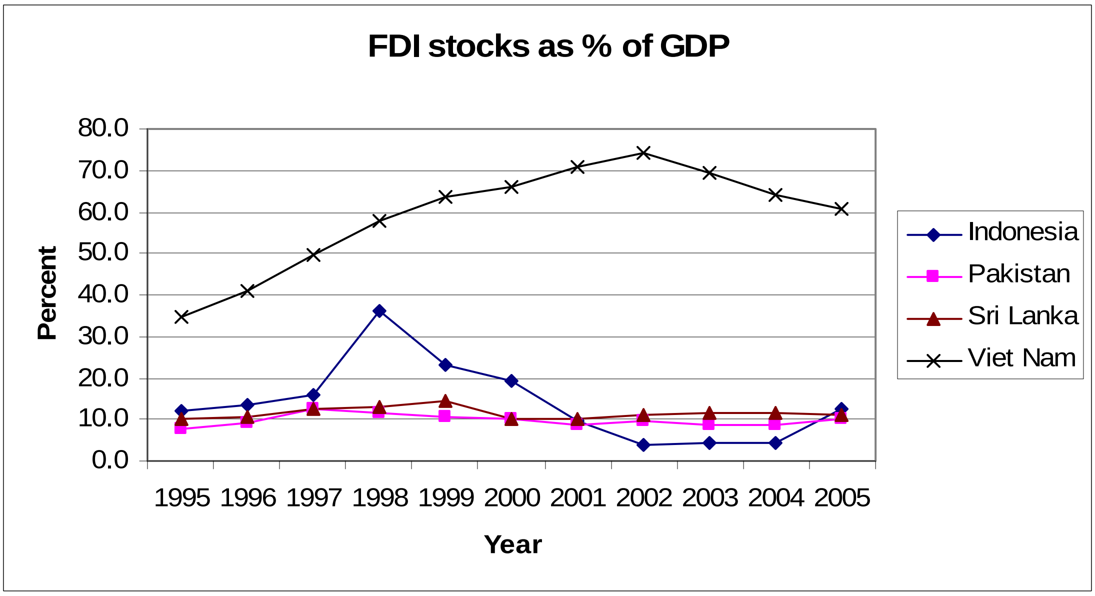
Figure 9.3 presents agricultural trade as a percentage of agricultural GDP to obtain an impression of the openness of the agricultural sector. Sri Lanka and Vietnam have similar scores in 2004, but Vietnam's has risen rapidly from a low level, while Sri Lanka's has declined from much higher levels. In the case of Sri Lanka the export performance is determined largely by tea which accounts for 75 – 80% of all agricultural exports by value (Sri Lanka Tea Board). Indonesia's agricultural trade has been flat since 1980 and Pakistan's has actually halved as a percentage of GDP over the period.

Figure 9.1 Trade as a percentage of GDP



Source: UNCTAD 2007

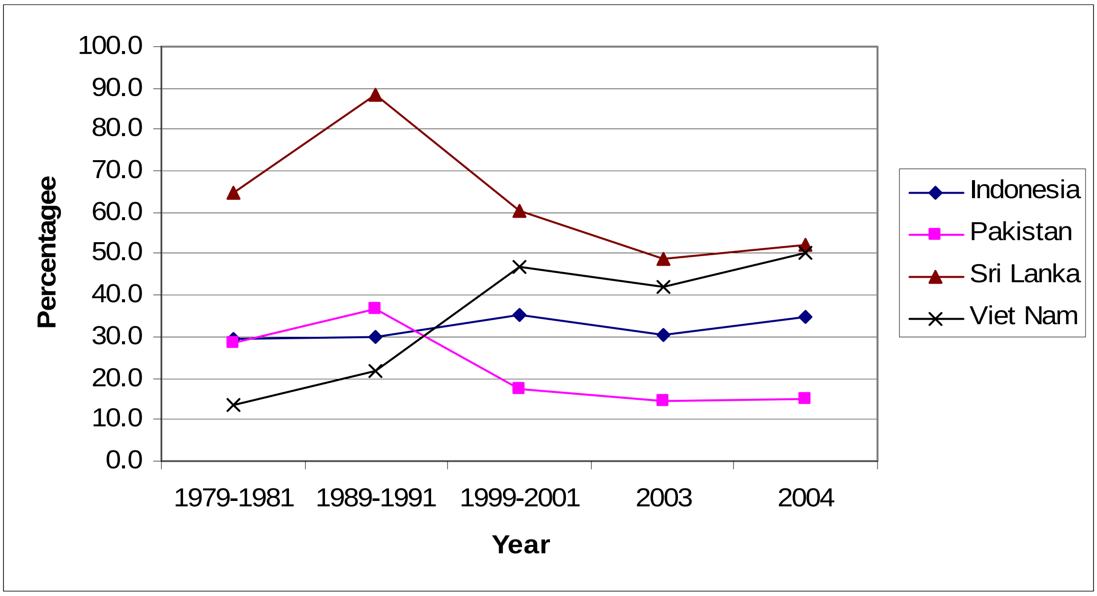
Figure 9.2 FDI stocks as a percentage of GDP



Source: UNCTAD 2007

Figure 9.4 presents UNCTAD data on the inward FDI potential index. This index is based on 12 variables[51] which are expected to contribute to a country's potential to attract foreign investment. Pakistan and Indonesia have become less attractive since 1990. Sri Lanka's attractiveness has not changed and Vietnam has grown rapidly.

Figure 9.3 Agricultural trade as a percentage of agricultural GDP



Source: FAO Statistical Yearbook 2005-2006

9.3.2 Technical change in agriculture in four Asian countries

Ideally, an analysis of technical change in agriculture would use information on adoption and use of innovative agricultural technologies. These would include for example, the adoption of modern varieties, resource conservation technologies such as the adoption of zero tillage methods, and the application of modern biotech practices such as tissue culture. However, hardly any quantitative data is available and where information is available it does not cover a range of countries. This limitation applies to the established green revolution technologies and more so with regard to technologies related to the other paradigms[52]. This section presents as indicators information on the use of modern inputs, the adoption of integrated pest management, and end with a discussion on how different countries are accessing biotechnology.

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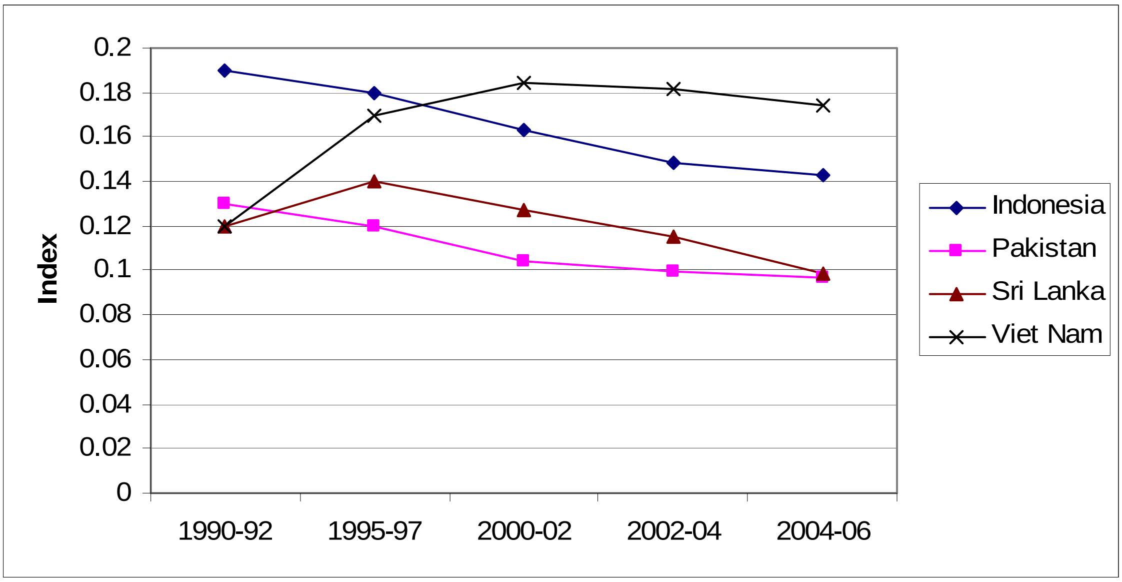
[51] The variables are: GDP, GDP growth, share of exports in GDP, number of telephone lines, commercial energy use, R&D intensity, university students, country risk, world share in exports of natural resources, imports of electronic and car components, service exports, and world share of FDI (UNCTAD 2007)

[52] Even the International Agricultural Research Centers of the CGIAR stopped publishing this kind of information. CIMMYT's World Facts and Trends reports on wheat and maize, have stopped appearing in 2000, and IIRI no longer monitors dissemination and adoption of its rice varieties.

Figure 9.4 Inward FDI potential index 1990 - 2006



Source: UNCTAD Inward FDI Potential data. Accessed October 2008 at: http://www.unctad.org/Templates/WebFlyer.asp?intItemID=2472&lang=1

Modern inputs
Some insights on technical change can be obtained from the World Development Indicators. Table 9.2 presents the limited information available on the use of modern inputs.

Table 9.2 Use of fertilizers and agricultural machinery

	Fertilizer Consumption (100 grams per ha. of arable land)			Agricultural Machinery (number of tractors /100 square km of arable land)		
Year	1989-91	2000-02	% growth	1989-91	2001-03	% growth
Indonesia	1227	1321	8	15	45	200
Pakistan	921	1377	50	127	154	21
Sri Lanka	2127	2862	35	75	113	51
Vietnam	1183	3172	168	51	245	380

Source: World Development Indicators 2006 (table 3.2)

The amount of fertilizer used per ha depends on a variety of factors: markets, types of crops and soil types and is difficult to compare. Vietnam reports a very high growth rate of fertilizer consumption, while that of Indonesia appears to be leveling off at a much lower rate. Considering mechanization it is Vietnam and Indonesia that are changing very fast with Sri Lanka and Pakistan growing much slower. Overall, most rapid change in the use of modern agricultural production technology is experienced by Vietnam, followed by Indonesia.

Integrated pest management

A number of technologies and resource management practices have been developed to promote sustainable agriculture. None of these has been more successful than Integrated Pest Management (IPM), an approach aimed to replace indiscriminate spraying of insecticides with careful monitoring of insect populations, the use of natural predators and other methods aimed at reducing the use of chemical pesticides. Since the late 1980s Indonesia has led the adoption of IPM practices in rice and in other crops. Most farmers were trained through Farmer Field Schools, which emphasize learning as opposed to the model of technology transfer that is dominant in the green revolution paradigm.

Data on the adoption and dissemination of IPM practices and their results are limited. Pontius et al. (2002) report that in Indonesia, since the beginning of the 1990s, more than one million farmers have been trained in IPM. Figures for Vietnam and Sri Lanka are 570,000 and 10,000 respectively. Achmad (2005) reports that in Pakistan, between 2001 and 2004, 14,000 farmers have been trained. Evidence as to the impact of IPM is quite mixed. Proponents of the IPM school report sharp reductions in the use of chemical inputs with yields that remain stable or increase (van den Berg 2004). On the other hand World Bank affiliated authors, such as Feder et al. (2004) in an assessment of the Indonesian experience find no effect on pesticide use, therefore no evidence of health or environmental benefits, and as a result no improvement in economic performance.

Perhaps the most interesting characteristic of the Indonesian IPM experience is that it was developed under the Government’s own auspices (Röling and van de Fliert 1998). The initiative was national, support from FAO was international. This contrasts with the model often used by the World Bank where institutional changes (e.g. the decentralization of agricultural research or the introduction of the T&V model in extension) were preconditions for the disbursement of major loans.

Biotechnology

The OECD in its 2003 report (OECD 2003) on accessing biotechnology in emerging markets uses two criteria to distinguish four stages of biotechnology uptake. The two criteria are biotechnology R&D capabilities, and the actual application of these capabilities in developing and marketing biotechnology products. Biotech R&D capabilities include experience in crop improvement, research capacity level (qualitative), the number of biotech patents and the number of scientists and engineers in agriculture. Use of the capacities is indicated by the number of biotech field trials (total and those by national institutes and organizations). The four country types are:

- **Non-selective importers of technology**: this is the situation in countries where there is no local capacity and initiatives are of an individual nature.
- **Selective importers of technology**: these countries have a basic research capacity in traditional crop improvement and have taken some steps towards developing local biotechnology capabilities.
- **Users of technology tools**: this includes countries with good plant breeding capacities, and who are able to release new varieties from their own crosses on a continuous basis. These countries use biotechnology tools in their crop improvement programs, including cell and tissue culture and marker assisted breeding.
- **Innovators**: countries in this group have research programs for both basic and applied research and development of new tools, as well as products in a wide range of crops and species (i.e. to develop new molecular markers, to conduct genomics work and to transform specific crops). This category includes countries with a science and technology system that can undertake frontier research and product development, and provide a continuous release of products through established links with product and input sectors. They also have good linkages to advanced research institutions in the developed world, which are often reflected in joint research projects.

These technology situations are then related to three possible market sizes: small, medium and large markets. As is to be expected, all of the four Asian countries have some experience in plant breeding and use of basic biotechnologies. The differences between Sri Lanka and Pakistan on the one hand and Indonesia and Vietnam on the other are mainly related to experience with GM field trials. By 2007 no GM field trials had taken place in Sri Lanka and Pakistan. Vietnam has had one trial on GM maize and Indonesia has experience with a total of eight trials, most of them managed by Monsanto and one of them managed by a national research institute.

Table 9.3 Biotechnology uptake by country type and market size

Market size Country characteristics	Small	Medium	Large
Importers of technology (non-selective)			
Importers of technology (selective / adaptation)	Sri Lanka		Pakistan
Tool users		Vietnam	Indonesia
Innovators			India, China

Source: OECD 2003

9.3.3 Institutional change in four Asian countries

This section covers three aspects of institutional change for which data are available at country level: intellectual property rights as established by international treaty, the regulatory environment for business, and the investment climate for business.

Intellectual Property Rights

A key aspect of institutional development is related to the dissemination of international standards of intellectual property right to the different countries. Table 9.4 provides an overview of country participation in different treaties under the World Intellectual Property Organization (WIPO).

Table 9.4 Membership of IPR treaties under WIPO

	Indonesia	Pakistan	Sri Lanka	Vietnam
WIPO Convention	+	+	+	+
Berne Convention	+	+	+	+
Paris Convention	+	+	+	+
Patent Cooperation Treaty (PCT)	+		+	+
World Copyright Treaty (WCT)	+			
Plant Variety Protection (UPOV)				+

Source: www.wipo.int

All four countries are WIPO members and have signed the Berne and Paris conventions on protection of literary and artistic works, and on the protection of industrial property, respectively. Beyond these, Pakistan has not signed any additional agreements. Indonesia, Sri Lanka and Vietnam are members of the Patent Cooperation Treaty which allows seeking patent protection simultaneously in a large number of countries – not highly relevant for countries that produce a limited number of patents. The two final treaties present interesting cases of domestic change under international pressure. First, Indonesia had been challenged since the 1980s (mainly from the USA) to put an end to copyright infringements. As a result of this, in May 1997 Indonesia joined the Berne convention and it was among the first countries in the world to ratify the WIPO Copyright Treaty (WCT) in 2002[53].

A second case of internationally induced institutional change is Vietnam, which has joined in 2006 the International Union for the Protection of New Varieties of Plants (UPOV) – the only country with China in developing Asia to be a member. Vietnam's membership of UPOV was an obligation under the US – Vietnam Bilateral Trade Agreement of 2001. And, as Vietnam became a member after 1998, it had to sign the 1991 version of the treaty. The 1991 UPOV amendments have been quite controversial as they have extended industrial type of IPR to plant varieties, strengthening the rights of plant breeders at the expense of the right of farmers to multiply and sell their farm saved seeds (the "farmer's privilege").

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[53] WCT is an extension of the Berne Convention which covers IP related, amongst others, to computer programs, databases and photographic works.

Although the number of cases is quite small, two observations can be made. The more open economies (Indonesia and Vietnam) have signed more international treaties on IPR. In addition, international pressure has in at least two cases played a significant role in pushing through institutional change at the national level.

Regulating business

The World Bank (2006a,b) has published since 2004 its annual Doing Business (DB) Reports. The reports focus on the regulatory aspects of opening, operating and closing a business. DB differs from other World Bank indicator sets such as Governance Matters in that it focuses more directly on the business environment. DB focuses on the following indicators:

- Dealing with licenses: building a warehouse
- Hiring and firing workers: employment regulation
- Registering property: regulation of property transfers
- Getting credit: legal rights and credit information
- Protecting investors: corporate governance
- Trading across borders: imports and exports
- Enforcing contracts: court efficiency
- Paying taxes: tax payable and compliance
- Closing a business: bankruptcy

DB differs from a number of other business indicator sets (e.g. the Country Risk Service provided by the Economist Intelligence Unit), which often rely on expert judgments in that it collects information about a standardized business case in a large number of countries. The DB methodology does not indicate the full range of issues and constraints and opportunities that a business faces (e.g. quality of the workforce, nearness to market, etc.). The DB standardized business is not very relevant to primary farm production (which, especially in the case of smallholders is part of the informal sector), but it would apply to industries that support the agricultural sector and which are becoming increasingly important in governance and vertical coordination; often at the expense of the role of public institutions (Swinnen and Maertens 2006).

Table 9.5 shows the rankings of the four Asian countries. In the overall rankings the relatively high positions of Pakistan and Vietnam and the relatively low positions of Vietnam and Indonesia stand out. Amongst others this begs the question: why are foreign investors (including those involved in agricultural innovation) flocking to countries such as Vietnam and Indonesia[54] where doing business is far from easy according to the DB rankings. Three explanations may be offered to explain this apparent contradiction. First, indeed other factors are important as well: education levels which are generally higher in Southeast and East Asian than in South Asia are important, but so is political stability as indicated in the Governance Matters indicators (a factor in both Sri Lanka and Pakistan). Second, the standardized business case in DB is a local limited liability company for which the rules and

[54] And China, whose rankings are comparable to those of Vietnam at 108 and 93 respectively in 2006 and 2007.

regulations are different compared to those governing major FDI projects, often established under specific laws and regulations and located in Special Economic Zones. Third, there are differences between sectors where agriculture is often more protected than others. Pakistan, for example, has put in place one of the most liberal economic regimes, but this does not (yet) extend to agriculture which continues to be suffering from structural rigidities in land tenure and control over resources. Fourth, and most important, the DB indicators are exclusively focused on the private sector and therefore not very useful for agricultural innovation where the public sector and civil society play a major role.

Table 9.5 Doing Business indicators 2006 and 2007[55]

	Ease of Doing Business Rank 2006	**Ease of Doing Business Rank 2007**	Starting a Business 2007	Dealing with Licenses 2007	Employing Workers 2007	Registering Property 2007	Getting Credit 2007
Pakistan	**66**	**74**	54	89	126	68	65
Sri Lanka	**89**	**89**	44	71	98	125	101
Vietnam	**98**	**104**	97	25	104	34	83
Indonesia	**131**	**135**	161	131	140	120	83

	Ease of Doing Business Rank 2006	**Ease of Doing Business Rank 2007**	Protecting Investors 2007	Paying Taxes 2007	Trading Across Borders 2007	Enforcing Contracts 2007	Closing a Business 2007
Pakistan	**66**	**74**	19	140	98	163	46
Sri Lanka	**89**	**89**	60	157	99	90	59
Vietnam	**98**	**104**	170	120	75	94	116
Indonesia	**131**	**135**	60	133	60	145	136

Source: *http://www.doingbusiness.org/EconomyRankings/*

The Global Retail Development Index

Developments in the agri-food chain can be approached from two angles: the country's potential as a supplier to international agri-food chains, and its attractiveness as a retail market for domestic and international supermarkets. Supermarkets play a key role in modernizing the production and distribution of food, not only for consumers in developed countries, but increasingly also for poor consumers in developing countries (Natawidjaja et al. 2006).

With regard to emerging markets' attractiveness for retail the consultancy firm A.T. Kearny publishes its annual Global Retail Development Index (GRDI), which shows for the top 30

[55] The 2006 data are from the 2007 report and differ from those published in the 2006 report as they are recalculated to reflect changes in methodology

emerging markets a composite index of risk and attractiveness. The GRDI is built on a large number of indicators grouped into four variables: country risk, market attractiveness, market saturation and time pressure (the latter indicating whether the country presents a short or a long-term opportunity). Table 9.6 shows that in 2005 three of the four countries in this study made it to the top 30 ranking.

In the 2006 index Vietnam has advanced from place 8 to place 3 in the ranking(which is again led by India), while both Indonesia and Pakistan have disappeared from the top 30 index as they were replaced by Kazachstan and Colombia. Sri Lanka does not appear in either the 2005 or 2006 index. At present no major international supermarket chains are present in the country (Perera et al. 2004).

Table 9.6 Global Retail Development Index (2005) [56]

Rank	Country	Country Risk	Market attractiveness	Market saturation	Time pressure	Score
	weight	*25%*	*25%*	*30%*	*20%*	
1	India	62	34	91	80	100
8	Vietnam	54	24	88	68	79
28	Indonesia	43	44	82	17	53
30	Pakistan	44	27	91	14	48

Source A.T. Kearny 2005

Looking at the indicators that make up the index a few key observations can be made:

- Vietnam is the riskiest country to invest, its market attractiveness is low (low incomes), and its overall highest score on the index is caused by time pressure: Vietnam presents an opportunity which may not last as many potential investors have set their eye on the country.
- Pakistan scores highest on market saturation (i.e. there are very few supermarkets), has low risk, but there is not much time pressure to invest in this not so attractive market.
- Indonesia has the most attractive market (incomes and size), relatively low risk, and low time pressure – because a number of major supermarket chains are already represented in the country.

Overall, Indonesia (with highest market attractiveness and highest market saturation) has moved farther than other countries towards an agri-food chain paradigm of agricultural innovation. Vietnam is starting from a low base, but likely to experience the most radical change in the next few years. Pakistan, on the other hand, is not likely to move very rapidly.

[56] Country Risk: 0 = high, 100 = low; Market attractiveness: 0 = low, 100 = high; Market saturation: 0 = saturated, 100 = not saturated; Time pressure: 0 = no time pressure, 100 = urgency to enter.

9.4 Conclusion: paradigms and countries

Finally, the question of how the four countries perform in relation to the paradigms is addressed.

Indonesia has been an early adopter of the green revolution which was promoted very extensively through a number of national and international programs. Seeing the problems of ever more intensive agriculture in rice production, the country also became an early adopter of sustainable approaches, especially the IPM program. Investment and the number of experiments with genetically modified crops put Indonesia ahead of other countries with regard to biotechnology. Obviously, Indonesia as a large relatively open country is an attractive market for life science companies. The same applies to the supermarket revolution: Indonesia has moved ahead further than any of the other countries in this study.

Pakistan's economy overall is the least open of the four countries, based on trade and investment patters (cf. figures 9.1. and 9.2) – although agriculture opened up since 1997. It has widely adopted green revolution technologies in rice and wheat and is implementing IPM practices – though on a much smaller scale than Indonesia. Biotechnology work is limited to some research undertaken in the public sector, but the presence of life sciences companies is small. Despite its size and its relatively good performance on business regulations it is not yet a very attractive country for supermarket chains.

Sri Lanka has a relatively closed economy (for its small size). Its adoption of green revolution technologies has leveled off, like Indonesia. Adoption of sustainable practices is low when taking into consideration the small number of farmers trained in IPM (even allowing for the Sri Lanka's small population size). Progress in biotechnology is limited and international supermarkets are not represented in the country.

Vietnam has increased its use of agricultural inputs at a very high rate since 1990. It was a later adopter than Indonesia of green revolution technologies, but its use of inputs is now very high and probably unsustainable in a number of cropping systems. Quantitative production goals (emphasis on rice and coffee exports) dominate the agricultural economy. But Vietnam is adopting sustainable technologies as evidenced by the large number of farmers trained in IPM. It should be noted that Vietnam, like Indonesia, is a large recipient of international development assistance which plays a key role in promoting IPM. Direct experience with biotechnology is more limited than Indonesia but the government is expanding its investment in science and technology rapidly and life science companies such as Monsanto are represented in the country. Also, Vietnam is the only country to have signed the most recent version of the UPOV agreement. Vietnam has the most open economy of the four and while incomes are still low and presence of modern retailers is still limited, this picture is changing very rapidly.

10. Public agricultural innovation actors in agricultural innovation

10.1 Introduction

Agricultural innovation involves a wide variety of actors: public and private research and extension organizations, producers of primary products, processors, consumers, NGOs, governments, and international organizations. Innovation systems can be seen as composed of technology and production subsystems, and a regulatory framework that is part of the selection environment that shapes innovation processes. This chapter discusses the core public innovation actors, with an emphasis on public agricultural R&D organizations. Private and non-profit actors are discussed in Chapter 11.

The role of public agricultural research is introduced by a discussion of public agricultural research investments, globally and in Asia (section 10.2 and 10.3). It is followed (in 10.4) by a more detailed analysis of public agricultural research in Indonesia, Pakistan, Sri Lanka and Vietnam, looking at governance, structure and organization, funding and performance. Section 10.5 analyzes in more detail the performance of a number of agricultural research organizations in terms of outputs and management characteristics. Conclusions are presented in 10.6.

10.2. Global investments in public agricultural R&D.

For a long time there has been a general impression that public investments in agricultural research and innovation are “in decline” (Pray and Umali Deininger 1998, “stagnating” (Byerlee et al. 2002), or even “collapsing” (Shand 2001). Alston, Pardey and Roseboom (1998), state that “[t]he past 25 years have witnessed an overall rapid growth in real support for agricultural R&D in rich and poor nations and in the international centers” but warn of “reduced support” and “tighter funding” for agricultural research.

Recent figures (Pardey et al. 2006 in Table 10.1) show that agricultural research investments in developing countries have held up pretty well until 2000 with an annual growth rate of 3% for developing countries[57]. In many countries however, while research expenditures continued to grow, they have declined as a percentage of AgGDP, indicating inadequate support to the requirements of a more knowledge intensive agriculture. Although no more recent overall data are available, there is no reason to believe that growth has slowed since 2000, especially not in the Asia-Pacific region, for at least two reasons. First, the Asian financial crisis from 1997-1998 caused a reduction of public expenditure figures, which has since been reversed. Second, a number of Asian countries have since 2000 declared science and technology a strategic priority and have significantly expanded investments, including in agricultural research and development (National Science Foundation 2007).

[57] Subsaharan Africa and the Middle East being the exceptions.

Table 10.1 Public agricultural research expenditures 1981 – 2000 (million 2000 PPP dollars)

	Expenditures			Annual growth rates (percent per year)		
Year	1981	1991	2000	1981-91	1991-2000	1981-2000
Developed Countries	8,293	10,534	10,191	2.27	–0.58	1.10
Developing Countries	6,904	9,459	12,819	3.20	3.09	3.14
Asia-Pacific	3,047	4,847	7,523	4.33	3.92	4.19
Total	15,197	19,992	23,010	2.63	1.20	2.11

Source: Pardey, Alston and Piggot 2006.

Table 10.2 shows how agricultural research expenditures are divided between the public and private sector. The key difference is between developed and developing countries: while in the former the share of sectors is rough equal, in developing countries, including Asia, over 90% over agricultural research is based on public funding.

Table 10.2 Public and private agricultural research expenditures by region 2000

	Agricultural research expenditure (million PPP dollars)			Share of total expenditure (percent)	
Region	Public	Private	Total	Public	Private
Industrialized world	10,191	12,577	22,767	44.8	55.2
Developing world	12,819	869	13,688	93.7	6.3
Asia-Pacific	7,523	663	8,186	91.9	8.1
Total	23,010	13,446	36,456	63.1	36.9

Source: Pardey, Alston and Piggot 2006.

10.3 Agricultural research and development in Asia

Public agricultural research in Asia started with the establishment of botanical gardens in the early 19th century in Java (Buitenzorg) and Ceylon (Peradeniya). Until the 1960s both public and private agricultural research focused on plantation and export crops. In the second half of the 1960s a major shift took place towards public agricultural research and towards food crops. Famines such as in India in 1967 prompted Malthusian fears of exponential population growth and linear growth in food production (Myrdal 1968, Meadows 1972). Donor budgets for international development assistance increased rapidly. Agricultural research and development became an international priority and focused on the further development and broad dissemination of the high yielding varieties of wheat, maize and rice that had been under development in Mexico and the Philippines since the 1940s.

Public agricultural research organizations were expanding rapidly in the 1970s and early 1980s, and large numbers of Asian agricultural researchers received training in the USA, Europe and Australia. The 1960s and 70s were the era of government-led development, and private agricultural research organizations in a number of countries (e.g. plantation crop research in Sri Lanka and Indonesia) were brought under government control.

By the early 1980s, in response to rapidly rising oil prices in the late 1970s and sharp falls in agricultural commodity prices on which many developing countries depended for export earnings, a period of "structural adjustment" started with an emphasis on sound government budgets, realistic exchange rates and more attention to the role of the private sector (Tabor 1995). Growth in public sector expenditures was reversed in many developing countries and, faced with an inability to reduce staff numbers, the only option for public research organizations was to squeeze operational expenditure to levels where virtually no meaningful research work could be undertaken. In many Asian countries (Indonesia, Sri Lanka, Pakistan and others) international donors stepped in to fill the gap and provided soft loans and grants to support agricultural research and extension. In Indonesia for example, in the second half of the 1980s operational funding for agricultural research was almost completely donor funded. While this kept the research system going in times of financial hardship, it also gave the donors considerable influence on operational spending and therefore on research priorities (Alirahman and Tabor 1993).

In many countries, including Indonesia, Sri Lanka and Pakistan, donor funding was also used for institutional capacity building, especially to coordinate the work of a host of institutions under a single national "apex body"[58]. While these governance bodies differ considerably in the roles that they play in the agricultural research and innovation system, they have had two main effects: improved coordination of activities of those components of the innovation system under their control and, in general, a centralization of decision-making.

By the late 1980s it became clear that centralized research bureaucracies could not address many of the new demands on the agricultural research organizations: a more knowledge intensive agriculture, a growing role of the private sector, new regulatory frameworks in relation to internationalization, a broader research agenda (including the need to address environmental concerns and making agricultural research relevant to poverty alleviation).

In reaction, donors and national governments started to implement a number measures to improve performance and accountability and to open up research systems. These included:

- Separation of research funding from research implementation,
- Introduction of competition between research providers,
- Involvement of technology users in planning and priority setting,
- Promotion of partnerships between public and private actors,
- Decentralization of research, and
- Building global scientific linkages

[58] The Indonesia Agency for Agricultural Research and Development (IAARD), The Pakistan Agricultural Development Council (PARC), and the Sri Lanka Council for Agricultural Research Policy (CARP) are examples.

Since the late 1990s these elements have formed the basis for the search for a new paradigm to govern and organize national agricultural research systems (Byerlee 1998). However, as the following section will discuss, the old centralized institutions, structures and top-down decision-making processes are quite resilient and resistant to change. As a result, limited progress has been made in the design and implementation of alternative governance and management models for agricultural research and innovation[59].

10.4 Public agricultural research in four countries

In most Asian countries over 90% of agricultural research expenditures are public sector based – therefore public agricultural research organizations are a key component of the agricultural innovation systems. This section discusses the main elements of the governance of public agricultural research in Indonesia, Pakistan, Sri Lanka and Vietnam.

For each country the discussion starts with an overview of the organization and structure of agricultural research, focusing on internal and external decision-making and coordination and linkage mechanisms. This is followed by a presentation of funding and expenditure patterns, that are important in steering research. In conclusion a few observations are presented on how governance issues affect research performance.

10.4.1 Indonesia

From the mid-1960s to mid-1980s, the principal objective of the Indonesian government was to attain self-sufficiency in rice production. The Indonesian Agency for Agricultural Research and Development (IAARD), established in 1974 to coordinate and implement national agricultural research, was put in charge of the rice research program. Thanks to the introduction of high-yielding varieties, the expansion of irrigation systems, formation of cooperatives, and the provision of credit facilities, and heavily subsidized agro-chemicals self-sufficiency was achieved in 1984 – although since then Indonesia has again become a rice importer.

Having made significant strides in rice production, IAARD, began in the mid-1980s to focus its attention on the development of secondary food crops, including maize, cassava, sweet potato, soybean, groundnut, and horticultural commodities. Some of these commodities have seen a significant increase in production over the years, especially maize, which is the country's second main staple food after rice and a key ingredient in the preparation of animal feed for the rapidly increasing poultry sector. The livestock and fisheries sub-sectors have also assumed increased importance, with significant gains made particularly in shrimp production.

[59] Latin America has gone further with institutional reform of agricultural research than Asia. The main reason is that pressures for reform were more severe than in Asia where public sector bureaucracies remained largely intact.

Governance
In the 1980s the IAARD structure was based on a number of high-level centers (food crops, industrial crops, horticulture, soils, socio-economics, and livestock). All were located in the Jakarta-Bogor area. Each center consisted of various institutes where the actual research was carried out. Under the Central Research Institute for Food Crops (CRIFC), for example, there were five regional food crops research institutes based in different locations. This structure had several problems. First, it was highly centralized, with most decision-making taking place at the central/national level. Second, most of the regional institutes had a mixed mandate, with national level responsibility for one or a few commodities and responsibility for all commodities in the region were the institute was located. In practice, the regional institutes did not have the capacity to fulfill their national-level commodity mandate. Third, insufficient attention was given to interdisciplinary work and to technology transfer. Finally, there was a bias towards Western Indonesia, which meant that the poorer regions in Eastern Indonesia were neglected.

IAARD was re-organized in 1995-96. Its new structure consisted of a secretariat, five non-commodity research centers, 16 national commodity institutes (grouped under five coordinating bodies), and 17 regional technology assessment institutes/stations. Central to this reorganization was the devolution of IAARD's adaptive research and extension responsibilities to these 17 Assessment Institutes for Agricultural Technology (AIAT), operating at the provincial level. The reorganization was driven to a large extent by international donors. The World Bank, which had been a major supporter of IAARD, made continued support conditional upon the reorganization – which was considered reluctantly by Indonesian decision-makers. Following the reorganization the World Bank and the Asian Development Bank both launched major projects in support of the newly created AIATs.

The overall purpose of the 1995-96 reorganization was to create a clearer separation between commodity and disciplinary research functions at the national level, and adaptive research and extension functions at the regional level. To this end the mandates of the commodity institutes were revised to focus on upstream, strategic types of research, while the new technology assessment institutes were charged with the responsibility to integrate adaptive research with extension functions in order to generate technologies relevant for local farming systems. The specific objectives of the restructuring were to:

- Improve IAARD coverage of different production systems in Indonesia, particularly in the resource-poor Eastern part of the country;
- More effectively integrate research and extension;
- More effectively establish linkages between research, agribusiness and farmer groups;
- Capitalize on Indonesia's regional diversity by developing location-specific technologies profitable to farmers;
- Increased attention to natural resource management in light of the growing environmental problems caused by population growth and rapid development.

In creating a structure that is both centralized and decentralized, IAARD has tried to consolidate the need to respond to national strategic goals on the one hand and to more immediate and specific problems at the regional level on the other. Implementation of this dual structure has proved to be a major challenge. Some of the problems associated with IAARD's 1995-96 reorganization include:

First, coordination and linkages between the national commodity research institutes and the regional technology assessment institutes (AIATs) was problematic, especially in the early years. It is clear that in a centralized-decentralized system, linkages within and outside the system need to be planned and managed very carefully – and this has proven to be a complex task. Second, in the early years, the achievements of the AIATs in linking with agribusiness and farmer groups have been limited. These linkage difficulties have been caused to a large extent by a lack of capacity within AIATs, particularly in the remote areas. Capacity problems stem mainly from the fact that there are too few resources for too many AIATs. Providing incentives to staff to live and work in the remote areas has also proved difficult. At the same time the national commodity institutes found themselves deprived of effective communication with farmers, since this was now the task of the AIAT. Third, supervision of the AIATs was initially the responsibility of the Center for Agro and Socio-Economic Research (CASER)[60]. This role has proved a major task for CASER, resulting in a neglect of its core socio-economic research work. Since 2004 management of the AIATs has become the responsibility of a newly created national level unit: the Indonesian Center for Agricultural Technology Assessment and Development (ICATAD). ICATAD coordinates the activities of the AIATs throughout the country, the number of which has now grown to 30.

Since 1999 a number of laws have been introduced to decentralize powers in Indonesia to the regions. Once on of the most centralized countries in the world, Indonesia decentralized many powers to the 350 counties (kabupaten), bypassing the provincial level in many cases. For several years the decentralization of the AIATs to the provinces, as part of the broader decentralization effort has been on the agenda. As it turned out that the provinces were neither ready to fund the AIATs, nor capable of providing technical support and supervision, the assessment centers have remained under IAARD, coordinated by ICATAD.

At present IAARDs organizational structure includes eight central research and development institutes with functions to manage research and development on food crops, horticulture, estate crops, livestock, soil and agro-climate, machinery development, post harvest and biotechnology. Other institutes address agro-economic and policy research, library and information and coordination of the AIATs established. Five private institutes for estate crops conduct research on sugar and sugarcane, coffee and cocoa, oil palm, rubber, and tea and cinchona. These research institutes are under the Indonesian Research Institute for Estate Crops (IRIEC), but technically under supervision of IAARD. Forestry and fisheries research is done under the respective line ministries.

Finance

Since the 1980s when Nestel (1985) referred to AARD as being synonymous with the national agricultural research system, not much has changed. IAARD with over 3000 staff continues to be both by far the largest public research organization in Indonesia and the most important actor in the agricultural innovation system with over 50% of all research

[60] Since renamed as Indonesian Center for Agriculture Socio Economic and Policy Studies (ICASEPS)

expenditures (table 10.3). Estate crops and forestry together are considerably smaller than IAARD. Universities play a minor role in doing agricultural research – their main task is education. Similarly, although growing in importance, private companies (see chapter 12**)** and international organizations are small research performers. Foreign donors, though, continue to be quite important, funding around USD 80 million, around 70 million of which goes to IAARD and 9 million to international organizations doing research in Indonesia.

Table 10.3 Estimated expenditures of research performers Indonesia (ca 2000)

Executing agency	Institute	Amount *(in million 1999 PPP dollars)*
Government Ministries	IAARD institutes	144
	Estate crops	65
	Forestry research	20
Agricultural Universities		22
Private for-profit companies		18
International organizations and NGOs		9
Total		278

Source: Fuglie and Piggot 2006

Performance issues

In the 1980s agricultural research, in combination with extension, irrigation investment, fertilizer and pesticide subsidies made major achievements in production growth, most notably in rice. In recent years the widespread adoption of IPM has been another important success story. But the widespread dissemination and adoption of locally adapted new technology, which was one of the major objectives of the creation of the AIATs has not yet materialized. It can be argued that the 1996 reorganization has had an adverse effect on innovative performance for a number of years as it created uncertainty over roles and responsibilities of national level commodity institutes and regional level technology assessment institutes and how to coordinate actions between them. The preoccupation with and the difficulty of internal coordination also had an adverse effect on the creation of linkages with non-research actors in the innovation system. The 2005 Asian Development Bank country evaluation has this to say about the project supporting the AIATs: “Although the AIATs have put together a diverse range of technology packages, the farm level transfer of technology has been limited. In part, this is due to shortages of extension workers, and the [Mid Term Review] argued that the project needed to design an extension vehicle to extend successful research results to farmers” (ADB 2005). This is a highly interesting observation and an implicit recognition of failure, as the AIATs were intended to be just that vehicle.

10.4.2 Pakistan

After partition and independence in 1947, Pakistan was left with very little of the agricultural research infrastructure of the former British India. Not a single central institute remained in Pakistan. The only research establishments in Pakistan at the time of independence were provincial agricultural research stations that were established to undertake applied and adaptive research on the agricultural commodities of the provinces. Since the 1950s an agricultural research and extension system has been developed, with strong support from international donors, especially the USA.

Governance

The public agricultural research system in Pakistan is organized at the federal and provincial levels. A very large number of institutes had been established: 74 research establishments at the federal level and 106 research institutions at the provincial level by the late 1990s, although some consolidation has taken place since then.

Following the recommendations of different committees and review teams the federal government established the Pakistan Agricultural Research Council (PARC) in 1978. According to its mandate, PARC is an autonomous research organization funded by the Federal Government under the Ministry of Food, Agriculture and Livestock. The main tasks of PARC relate to providing governance and coordination functions for the agricultural research system. But increasingly, the need was felt for PARC to engage more directly in research activities of a strategic nature. Thus the first task as described in the PARC Ordinance of 1981 is to “undertake, aid, promote and coordinate agricultural research”. At present there are three research centers under PARC: the National Agricultural Research Centre (NARC) in Islamabad (the largest and most developed center of PARC with 9 institutes), the Arid Zone Research Centre (AZRC) in Quetta, and the Southern Zone Agricultural Research Centre (SZARC) in Karachi. In addition, PARC runs a regional research institute in Gilgit, and specialized centers working on tea and on technology transfer.

Provincial research institutes carry out applied research and these are more geared towards development activities rather than hard core scientific research. Each province has a central, multi-disciplinary research institute for crops; these are located at Tarnab, Faisalabad, Tandojam and Sariab-Quetta. Most of the other provincial institutes are commodity oriented experimental stations with a few working on multiple disciplines. Agricultural research undertaken by private sector is very limited in Pakistan (Ahmad and Nagy 2002). Some fertilizer and pesticide industries have set up demonstration plots and provide advisory services, linked to their range of products.

Under the Constitution of Pakistan, agriculture is a provincial subject. This has sometimes resulted in confusion and at times the existence of PARC has been questioned. However, according to the constitution, research, training and special studies are federal tasks. Furthermore, national planning and national economic coordination – including planning and coordination of scientific technological research – is also part of the federal agenda. Thus, the role of PARC in the national agricultural research system (NARS) is that of a coordinating, planning and reviewing agency that also provides funds for contract research to all components of the NARS. Acquiring and sharing information is another important function of PARC. The PARC in-house research agenda has to originate from provincial research agenda and should include hi-tech research areas and disciplines beyond the capabilities of provincial research.

In spite of being an autonomous organization, PARC faced serious problems in carrying out its duties, particularly in coordinating agriculture research with the provinces. Furthermore, many other problems like training, budget allocations and communication with stakeholders in the federal and provincial governments emerged. The reason was that decision-making is very hierarchical and centralized, often resulting in long delays. Realizing the difficulties agriculture research was facing and in order to expedite decisions for the improvement of agricultural research in the country, the Agricultural Research Division (ARD) was established in 1980 as part of the Federal Government in the Ministry of Food Agriculture and Lands (MINFAL), and the Chairman of PARC was designated as Ex-officio Secretary, ARD. In 1993, however, the ARD was abolished and reduced to form the Agricultural Research Wing and the PARC Chairman no longer held the position of Secretary to the Federal Government. At present, agricultural research in MINFAL is looked after by the Agricultural Research Section a much lower ranking unit than the former ARD. This is resulting complicated and slow decision making and long delays.

A review of the governance of PARC conducted by senior officials of PARC itself states that the Council is facing a severe governance crisis (Afzal et al. 2003). The study pointed out the following governance issues in PARC:

- Effective autonomy of PARC: with the abolition of the Agricultural Research Division in the Ministry, PARC now reports to a middle level manager in the Ministry. PARC’s autonomy appears to exist on paper only.
- Effectiveness of the PARC Board of Governors: since all decisions have to be approved by MINFAL the role of the Board in shaping policy is quite limited – the Board therefore limits itself to technical matters.
- Coordination among different components of the NARS. The research system in Pakistan is a patchwork of institutes under federal and provincial governments, and universities. This leads to limited information exchange and duplication of research efforts. PARC does not have the necessary authority to coordinate this complex setup.
- As a result linkages between federal and provincial research, between research and extension and between research public and private sector are weak.
- Career structure for scientists. Researchers are civil servants and in recent years significant numbers of researchers have left research positions, because of low salaries and limited career opportunities. Promotions are usually based on seniority rather than on qualifications.

Finance

Funding for agricultural research and extension is almost entirely from government sources. Donor contributions have fluctuated, experiencing severe reductions after the nuclear tests in 1998 and improving after 2001.

The main trend is that PARC’s development expenditures have declined sharply while non-development expenditures (mainly salaries) have increased over the years. PARC development expenditures reached a low of PRs 26 million (USD 483,000 at current exchange rates) in 1999. PARC’s financial situation improved since then as seen in Table 10.4. A key characteristic is that over 90% of the budget is spent on salaries and allowances, leaving very little room for research operations and investments.

Table 10.4 PARC Expenditures 2004-2005

Type of expenditure	PRs (million)	USD million (current exchange rates)
Current expenditures	458	7.6
Operational	32	0.5
Development expenditures	160	2.7
Total	650	10.8

Source: PARC website: http://www.parc.gov.pk/, accessed August 2007

Additional funding for agricultural research is from provincial governments and from universities. The Government of Punjab, for example, by far the most important agricultural province in the country, in 2006 allocated PRs 280 million (USD 4.6 million) to agricultural research and the same amount to extension (Daily Times, 15 June 2006).

Performance issues

Key issues that affect the performance of PARC and its research institutes thus relate to inadequate (operational) funding, overly centralized decision-making, difficulties in internal and external coordination and communication. Specifically, PARC's inability to provide basic governance functions to a fragmented agricultural research system is problematic. This translates into problems in staff morale and, more importantly, inadequate services delivered to clients.

In an evaluation of the Pakistan agricultural sector for the Asian Development Bank Greer and Husaini Jagirdar (2006: 5) assert that:

> "[s]ervices related to research and extension provided by most federal and provincial agencies follow a traditional top-down approach. The services are generally perceived to be ineffective and inaccessible to end users, especially small farmers and entrepreneurs. There is also duplication of research activities and lack of coordination between overlapping institutions. Moreover, more than 90% of the budget is allocated to salaries, leaving less than 10% for administrative expenses and operational costs. […] The weakest institutional link is the transfer or flow of higher production technology and packages from research institutes to agriculture extension providers, and onwards to the farmers."

As discussed in Chapter 8, Pakistan's agricultural sector has grown very healthily in the decade since 1997. This is mainly the result of a comprehensive and successful set of policy measures aimed at removing market distortions. A conclusion is that while there are some remarkable research successes (e.g. in wheat breeding and in crop disease management), on the whole the research system has not delivered a sufficiently broad range of new technologies and practices to farmers. As the agricultural continues to grow farmers' needs for technology and research-based solutions will continue to grow as well.

10.4.3 Sri Lanka

Agricultural research in Sri Lanka has a long tradition dating back to the establishment of botanical gardens in Peradeniya in the 19th Century. The establishment of research institutes started in the early twentieth century. Between 1910 and 1928, the Rubber Research Institute (RRI), the Tea Research Institute (TRI), and the Coconut Research Institute (CRI) were founded. The Sugarcane Research Institute (SRI) was established in 1984. Sri Lanka was also a very early starter with research on food crops with the establishment of the Department of Agriculture (DOA) in 1912.

Governance

The main characteristic of Sri Lanka's agricultural research and extension system is its fragmentation, which reflects a proliferation of ministries and a constant reorganization of departments under ministries, often to suit individual politicians. At present there are 53 ministries, nine of which deal with agriculture and rural development. Most of these also undertake some research and/or extension activity. Other research actors are universities and their departments of agriculture under the Ministry of Education. Extension at the provincial level is under the responsibility of eight Provincial Councils. Finally, the Ministry of Science and Technology also provides some funding for agricultural R&D.

To coordinate research efforts and to act as an umbrella organization, the Council for Agricultural Research Policy (CARP) was established in 1987. CARP's creation was partly the result of the influence of World Bank, which made the existence of a Council a requirement for funding a major agricultural research loan. The creation of CARP, its status, role and position in the NARS was rather controversial in the research community (and followed two earlier unsuccessful initiatives to establish a coordination mechanism). The way that CARP has been set up is the result of a political compromise and reflects the fragmented nature of the research system.

CARP is a semi-autonomous council under the Ministry of Agriculture, supported by a secretariat. A complication is the fact that CARP is supposed to co-ordinate a public agricultural research system, the organisations of which belong to five different Ministries, while CARP itself is placed under one of these five ministries i.e. the Ministry of Agriculture, Livestock, Lands and Irrigation. Also, with the exception of the funds made available for the competitive Contract Research Programme (CRP), CARP does not have any control over the allocation of funds to the individual institutes it is supposed to co-ordinate. In this respect, CARP cannot be regarded a governance body for the research system. It does not have the authority over the organisations that form the NARS and for which it is required to play a coordinating role. Consequently, if CARP is to play a role of co-ordination and integration in the NARS it will have to be on the basis of other strengths.[61]

CARP also differs from all other Asian agricultural research councils because of its very small size and the limited resources of the secretariat (which has only 12 staff members). This

[61] The question may also be asked about the continued relevance of the objective of building a single integrated NARS, which formed the rationale for creating CARP in the 1980s. These days, in many countries, competition, rather than coordination is seen as the most adequate mechanism to promote high-quality research that is relevant to stakeholders.

limits CARP's role as a player in the institutional landscape. Many other Asian research councils have become large bureaucracies in themselves, even to the extent that by their bloated size, complexity and organisational culture they have become unable to provide the research system with guidance and vision. CARP, however, is at the other extreme: it cannot nearly cover the activities described in its mandate. As a result, CARP has played a niche role concentrating on services and moving downstream, i.e. towards research implementation and service provision, rather than upstream towards coordination and research policy advice. This may have been necessary given the fact that CARP started as a controversial institution and has to gain acceptance and credibility before becoming involved in more strategic policy issues.

The Council has 13 members representing a large number of public sector organizations. The composition of the Council is heavily biased towards the public sector, and towards the research system. There is only one slot to represent the private sector, and this position had not been filled for many years. There is no representation of NGOs on the Council, and the position reserved for the smallholder farming sector is filled by a civil servant. Thus, the membership of the council is lopsided and it reflects a set of actors that is immediately concerned with research matters. If CARP is to play a role as a network organization, and if it is to broaden its current research perspective towards innovation, it will have to become more outward-looking. Broadening the participation of organisations of a different nature is one way to help achieve this. Another is by developing external linkages and alliances more strongly.

Concerning the issues of accountability and relevance to stakeholders, the general conclusion must be that CARP has limited itself to a rather narrow range of stakeholders, in particular the traditional public sector NARS. This may be explained by the fact the small CARP Secretariat has faced an up-hill battle to coordinate activities between the five Ministries involved in research, and has lacked the capacity and resources to expand beyond this range of actors.

Finance

In absolute terms expenditures on agricultural R&D have grown at about 2% per year since 1980. In relative terms however agricultural research expenditures as percentage of AgGDP have steadily dropped from 0.66% in 1981 to 0.36 % in 2003 (Stads et al. 2005). Over the same period, many other Asian countries have increased their relative investment levels significantly. Sri Lanka appears to be falling behind other countries in supporting a more knowledge intensive agriculture. The funding trends are reflected in other characteristics such as quality of staff. A substantial number of the researchers do not have post-graduate degrees (MSc or higher) and the educational profile of research staff at government establishments has not improved in any significant way over the past ten years.

The agricultural research system of Sri Lanka shows a dualistic structure, dating back to the times that the plantation crop research institutes (working on tea, rubber, coconuts and sugar) were private. Nationalized in the 1960s, they have managed to retain some of their former characteristics. Their governance and funding is different from the food crops research institutes under the Department of Agriculture. Plantation crop research institutes are managed by a Board with significant representation from the producers, ensuring that research is relevant to the needs of the sector. Funding of the plantation crop research institutes is partially through an export levy (the “cess”) that channels a small percentage of export revenues directly to research. In the case of tea for example 25% of cess revenues of SL Rs 2.50/kg goes to fund the Tea Research Institute (Stads et al. 2005). As a result plantation crop research is significantly better funded than food crop research. This translates both into higher salaries for researchers at these institutes and into higher operational budgets per researcher. Table 10.5 shows that funding for plantation crop research is higher than for food crops while the number of staff at these institutes is significantly lower.

Of the total agricultural research budget 70% is directly from government, 20% from cess revenues and 10% from a variety of sources including own revenue, international donors and contract research. CARP manages a Competitive Contract Research Grants (CCRG) program, a fund that contains SLRs 100 million (around 10 million USD) for defined priority research areas. While it is an encouraging initiative, as a percentage of total research expenditure competitive grant funding remains small, as the fund is meant for a number of years. In addition, many researchers do not bother to apply because of the additional work required and the almost complete lack of rewards and incentives to undertake high quality research. Finally, as Table 10.5 confirms, private agricultural research in Sri Lanka is negligible, and limited to a single company: CIC Agribusiness.

Table 10.5 Composition of agricultural R&D expenditures and researchers, Sri Lanka 2003

	Total spending *(2000 international $)*	Total researchers *(fte's)*	Share in spending	Share in research staff *(percentage)*
Public agencies				
Ministries of Agriculture and Livestock	23.1	338.0	38.1	58.4
Ministry of Plantation Industries	24.6	124.0	40.4	21.4
Other government	5.5	46.0	9.1	7.9
Higher education agencies	7.3	69.2	11.9	11.9
Subtotal	*60.5*	*577.2*	*99.5*	*99.7*
Business enterprises	0.3	2.0	0.5	0.3
Total	*60.8*	*579.2*	*100.0*	*100.0*

Source: Stads et al. 2005

Performance issues

An important achievement of Sri Lankan agricultural research and extension is its contribution to achieving near self-sufficiency in rice – the country produces about 95% of domestic consumption. However, self-sufficiency in rice also owes much to inflexible land laws that do not allow rice lands to be used for growing other crops. Constraining the diversification of the agricultural economy, rice self sufficiency has come at a high price and explains at least partially why Sri Lanka is falling behind other Asian countries in producing and exporting high value crops such as fruits and vegetables (ADB 2007).

The agricultural research and extension system of Sri Lanka does not appear to achieve significant impact. Fragmentation of the research effort into smallish, uncoordinated bits is an explanatory factor. In addition, there are major coordination problems between research and extension as a result of devolving the responsibility for extension to the provinces in 1989. Linkage mechanisms between research and extension – and especially with other actors in the agricultural innovation systems – do not seem to be in place.

10.4.4 Vietnam

Agricultural research and development in Vietnam were very small in the early post-independence period. Investments were limited and qualified staff were few. There was a strong orientation on the Soviet Union in the way research was organized and funded. Foreign training programs were oriented on Eastern Europe. After the Doi Moi reforms of 1985, the agricultural economy was liberalized and the research system became more open to international exposure.

Since 1996 agricultural production has grown very rapidly, yet the share of agriculture in the economy has declined as other sectors (manufacturing) grew more rapidly still. Vietnam's Government has declared science and technology a key area of public investment and expenditures have grown very rapidly since 2000.

Governance

Unlike other countries in this study, Vietnam has not established a research agency or council, formally charged with coordinating agricultural research in the country. Agricultural research in Vietnam remains under the Ministry of Agriculture and Rural Development (MARD), specifically its Department of Science, Technology, and Quality Control (DSTQC) for technical issues. The Ministry Departments of Finance and Personnel also have a major influence on the way agricultural research is funded and managed. Besides MARD, the Ministries of Science and Technology (MOST), and the Ministry of Education and Training (MOET) are important actors. MOST is funding some 14 national level research programs (e.g. on rice, animal science) that involve different institutes. MOET is in charge of the universities, a number of which are also involved in agricultural research. The Ministry of Fisheries is in charge of four research institutes, three on aquaculture and one working on marine products. These employ relatively few staff (< 10% of researchers) but are responsible for over 25% of expenditure, mainly due to the heavy capital requirements for research vessels, equipment and facilities.

Until 2005 MARD maintained an agricultural research system made up of 29 research institutes. The research system is highly centralized geographically: 18 research institutes have their headquarters in Hanoi, and 3 in Ho Chi Minh City (HCMC). The other 8 research institutes are located in smaller towns, but often close to Hanoi or HCMC. The research institutes may have centers (or locations) in other parts of the country, but often these are also located close to Hanoi and HCMC: 40% of all locations are in Hanoi and another 13% are in HCMC (ISNAR 2000).

MOST influences the direction of agricultural research through its national agricultural research program. Projects are drawn up by project advisory committees consisting of specialists on the subject matter and are reviewed by a national committee with leading agricultural scientists. The national research projects help to overcome duplication problems as is clear in the case of rice, where the national project has distributed the responsibility for rice breeding in different environments across institutes.

A number of agricultural research institutes were formerly part of state owned enterprises (SOEs). Several of those have become part of the MARD system as the companies could no longer support the research infrastructure (e.g. the Research Institute on Fruits and Vegetables). Recently however, in a move to forge closer linkage with production, two MARD institutes (working on rubber and bee research) have been transferred to the Vietnam Rubber Corporation and the Vietnam Bee Company. Devolvement of other research institutes to the relevant industry is planned. As some of these SOEs are "equitized" (privatized), the related research institutes will become part of the private sector. At the moment private agricultural research is negligible. One exception is East-West Seeds, a Netherlands hybrid vegetable seeds company with headquarters in Thailand and research and seed production facilities in a number of SE Asian countries, including in Ho Chi Minh City.

A major restructuring of the MARD research system has been contemplated since the late 1990s and has been the subject of considerable discussion. The need for reorganization was expressed by the central government, where it was felt that there were too many institutes which did not work together in a coherent manner. The institutes were resistant to change and the discussion continued till 2005 when the 29 MARD institutes were consolidated into 14 new institutes. The biggest merger was that of 10 institutes into the Vietnam Academy of Agricultural Sciences. While the longer-term effects of the consolidation are not yet clear, one issue that is not addressed is the geographical concentration of research in the deltas of the Red River (Hanoi) and the Mekong River (HCMC). This leaves the poor, central region of the country underrepresented in terms of research facilities.

Finance

Funding for MARD institutes comes from three sources. First, as mentioned, MOST supplies funding for staff and operations through the national research programs. Second, MARD from it own sources, also provides funding for salaries and overheads to a number of institutes. Third, at many institutes income from commercial activities is important. This may concern seed, cross-bred animals, vaccines and the like, but also the production of food crops, cash crops and animal products for the market. The importance of this income source is more difficult to assess because MARD does not collect data on it. But from discussions with several research institutes, it became clear that the income from these commercial activities is often larger than the funding from the research activities. In contrast with other countries (where research institutes are usually not allowed to retain any proceeds from commercial activity) Vietnam actively encourages institutes to seek additional sources of income.

The importance of revenue from commercial activities is a unique feature of the Vietnamese research system. It originated in a pre-market situation where there was no agro-industry to provide inputs and the research institutes were the only organizations with the knowledge and the staff to produce, for example, high quality maize seed, coffee seedlings, or provide artificial insemination services. Another example of commercial activity is the National Institute of Animal Husbandry (NIAH) which has established an animal feed mill in a joint venture with a French animal feed company. Many of the NIAH research staff have invested in the joint venture and have become shareholders. These activities are frowned upon by some of the donors, notably the World Bank which insists on the use of public monies for the production of public goods, and which is afraid that commercial activities may crowd out the research work. While some Vietnamese research institutes indeed appear to be more in the business of commercial production than in research, an advantage of such arrangements is that they forge much closer linkages between research and production – a key problem in many Asian agricultural research organizations.

Until the end of the 1990s agricultural research in Vietnam was woefully underfunded. Vietnam's research expenditure as a fraction of AgGDP (0.12%) was one of the lowest in Asia, where the average was 0.58%. However, Vietnam's agricultural R&D expenditures increased from USD 28 to 80 million per year between 1996 and 2001, caused both by an increase in government contributions to financing agricultural research, as well as a strong growth in donor support (Stads and Hai 2006). Still, average expenditures per researcher and research intensity levels remain lower than in many other Southeast Asian countries. Both agriculture and science and technology are priorities for the Government of Vietnam and investments are increasing very substantially over the 2001-2010 plan period. Stads and Hai (2006) calculate that average spending per scientist more than doubled, from USD 14,000 in 1996 to USD 31,000 in 2001.

Another striking feature of Vietnam's research funding is that (again according to Stads and Hai) in the period 1996–2002 salaries accounted for an average of 19 percent of total expenditures of a sample of 28 government agencies. Operating costs represented 39 percent of the total, and capital costs, 42 percent. This contrasts sharply with other countries where salaries and allowances consume almost the entire budget. This pattern reflects a combination of two features: one is that capital expenses have increased significantly, while at the same time salaries are still extremely low, pushing down the wage component of the budget. To support researcher income the government has encouraged researchers to engage in consultancy work.

Performance issues

The Government of Vietnam has taken important steps to ensure that the dynamic agricultural sector will be supported by an effective technology generation and dissemination system. While close linkages between research and the productive sector are a major strength of the research system, a problem is that some institutes appear to be more engaged in commercial activity than in doing quality research. This is a legacy from the past when there were very few agricultural supply companies in a state-led economy. Commercial activities allowed researchers to supplement their salaries, which was convenient both to staff and to the government. While this may have been a pragmatic and effective solution in a closed economy with an undiversified agricultural sector, it may not be an adequate solution for a time when the economy has opened, the private sector is becoming an important supplier of inputs and Vietnam's export-oriented agricultural sector will have to compete at global level. The challenge will be to upgrade the quality of research work done, while retaining close linkages between research and production.

10.5 Performance of agricultural research organizations

This section takes a closer look at the performance of six public sector agricultural research organizations. The original performance assessment was done as part of an international project aimed at diagnosing and improving organizational performance of agricultural research organizations[62]. The analysis includes two institutes in Indonesia (one, the Research Institute on Rice (RIR), a national commodity research institute, the other a regional technology assessment institute (AIAT) in Central Java), two institutes in Pakistan (the Crops Diseases Research Institute (CDRI) and the Animal Science Institute (ASI)), and one each in Sri Lanka and Vietnam, the Coconut Research Institute (CRI) and the National Institute of Animal Husbandry (NIAH).

The analyses were conducted using a framework for measuring R&D effectiveness developed by Szakonyi (1994a,b), and elaborated for agricultural research organizations at the International Service for National Agricultural Research (ISNAR) as the Organizational Performance Assessment System (OPAS) (Peterson et al. 2003). The organizational performance assessment analysis was extended through the analysis of a questionnaire that was filled in by 17 directors and research managers representing the organizations included in the analysis. The fieldwork was undertaken between 2000 and 2003.

10.5.1 Organizational performance assessment methodology

Agricultural research organizations can be seen as research production systems, in which investment of resources leads to the production of outputs (Figure 10.1). The OPAS focuses first, on the evaluation of these outputs and second, on the analysis of the management processes that drive the production of these outputs. The methodology has been applied in a number of national agricultural research organizations worldwide. A key characteristic of OPAS is that it is a self-assessment system, aimed at improving organizational performance, rather than an external evaluation aimed at accountability.

The main purpose of **output assessment** is to evaluate organizational productivity in terms of research and service outputs, and to assess the extent to which these outputs contribute to the goals and objectives of the organization. The assessment is carried out in a number of steps that involve identification, measurement, and analysis of output data.

[62] The project on Performance-Based Management Systems (PBMS) for Asian Agricultural Research Organizations was implemented by ISNAR from 2000 – 2003 with funding from the Asian Development Bank (RETA 5866).

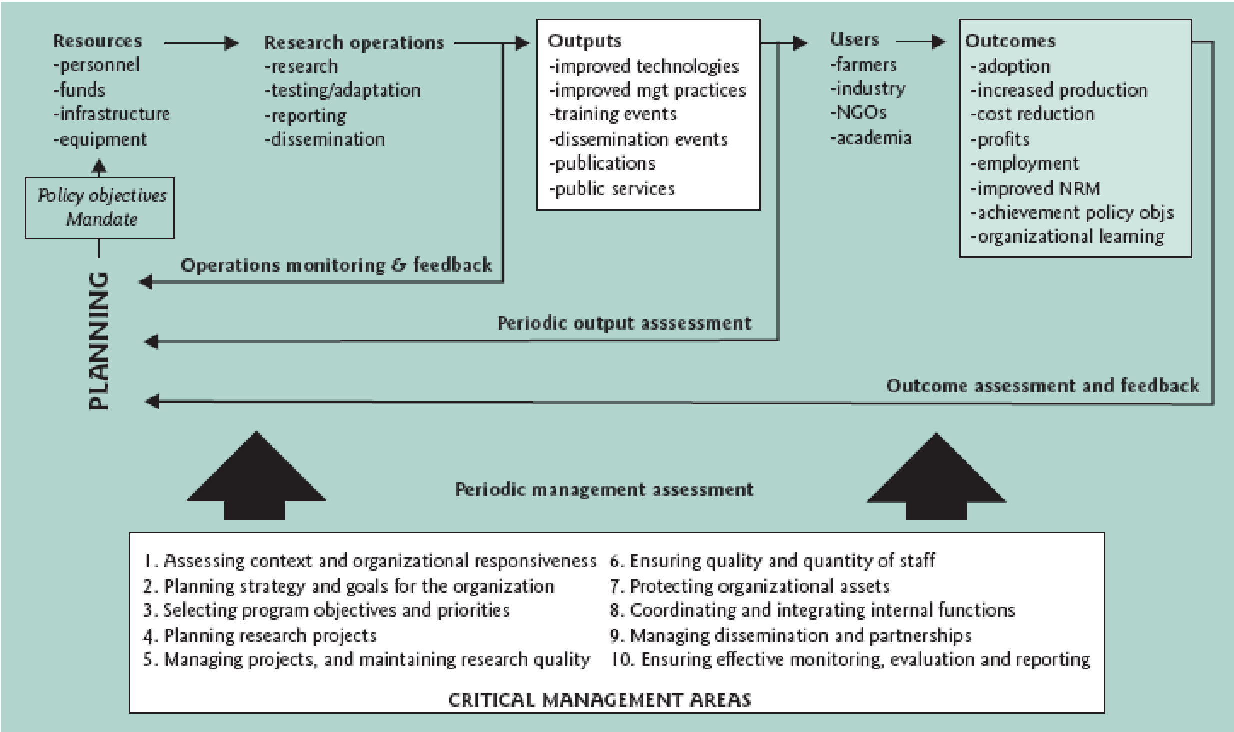
The assessment system has been designed in a generic manner to be applicable to various kinds of research organization, but it can be adapted to meet the specific needs of a particular organization. OPAS uses six broad categories of output that are common to most agricultural research organizations:

1. Production and research technologies (including, for example, improved crop or livestock varieties, new laboratory methods, and technologies for irrigation, pest control, and crop or livestock nutrition);
2. Crop or livestock management practices (captured as recommendations for improving crop or livestock health, store management, or nutrition);
3. Publications and reports (which can be broken down into categories such as scientific journal articles, training manuals, and consultancy reports);
4. Training events (intended for farmers, extension workers, or researchers);
5. Dissemination events (including field days, on-farm trials, interactions with the media, exhibitions, and seminars);
6. Public services (such as surveys for pests and diseases, land-use mapping, germplasm conservation, seed or vaccine production and distribution, quarantine and quality control services, policy studies, and student supervision).

Output categories and specific outputs in each category can be adapted to reflect the characteristics and needs of individual research organizations. Additional fine tuning, to reflect policy objectives and organizational priorities can be achieved by weighting the scores to reflect the importance of particular outputs to the organization.

The performance of an agricultural research organization is driven by a number of critical management factors as indicated in the lower part of Figure 10.1. **Management assessment** involves reviewing ten key planning, management, and decision-making processes within an organization. By assessing these ten key areas from time to time, managers can determine whether appropriate mechanisms and procedures are in place and functioning, and can take steps where necessary to correct any management deficiencies that are contributing to poor performance. The assessment is also designed to provide information on constraints to performance. These include internal, as well as external constraints (such as inadequate research funding and salaries, and cumbersome civil service procedures) that managers may not immediately be able to change themselves but that they can draw to the attention of higher-level decision-makers and thus expect to influence in the longer term. The assessment provides a rapid but thorough analysis of management strengths, weaknesses, and constraints.

Figure 10.1 Elements of Organizational Performance



Source: Peterson, Gijsbers and Wilks, 2003

The management assessment process, adapted from Szakonyi (1994b), is a semi-quantitative process that consists of a number of steps, which can be adapted to meet an organization's needs. For each of the 10 management areas, the OPAS proposes approximately 10 questions, which examine the organizational capacity and use of certain good practices. These questions are reviewed and adjusted to ensure their applicability and relevance.

10.5.2 The six institutes

The Research Institute for Rice (RIR) was established in 1972 as the Sukamandi Branch of the Central Institute for Agriculture (later the Central Research Institute for Food Crops, CRIFC), with a mandate to provide breeder seed to the national seed company. In 1980 it became the Sukamandi Research Institute for food Crops (SURIF), with the mandate to produce technology for the production of food crops, including rice, maize, and pulse crops. In 1995, with the reorganization of AARD, SURIF became the Research Institute for Rice (RIR) with the national mandate of developing and producing technology for rice. The most important outputs of the institute in the production technology area include the development and release of new rice varieties, the development of new cultural practices, the development of post-harvest technologies, and the management of biotic and abiotic stress in rice.

The institute is divided in four departments i.e. the Department of Germplasm and Plant Breeding, the Ecophysiology Department, the Department of Entomology and Plant

Pathology, and the Department of Post-harvest Physiology. RIR is located in one of the main rice production centers of Indonesia in Sukamandi, West Java. The total staff of the institute amounted to 421 in the year 2001. Research activities are carried out by 85 research workers (22 PhD, 28 Masters, and 35 Sarjana (comparable to bachelor degrees). The institute counted 33 senior administrative staff.

The **Assessment Institute for Agricultural Technology (AIAT)** at Ungaran, Central Java, together with 16 similar regional centers was established in 1995. The purpose of the AIATs is to conduct adaptive research and technology assessment and convert the results into location-specific agricultural technology packages for farmer's needs. AIATs aim to bridge the gap between upstream commodity research and the technology dissemination requirements of different (agro-ecological) regions, and provide feedback to the national commodity research institutes. To achieve this mandate, the AIATs integrate both research and extension staff.

AIAT Ungaran staff amounted to 313 persons of which 69 were researchers and 19 were extension staff. In the professional staff category there were 3 with a PhD degree, 19 with an MSc degree and 84 with a BSc degree or equivalent.

The Animal Sciences Institute (ASI), Pakistan is part of the National Agricultural Research Centre (NARC), located in Islamabad. Its purpose is to strengthen the national research efforts related to farm animals and its objectives are to conduct research in animal production and animal health, to develop and disseminate appropriate technologies to end-users (farmers, industry, other research institutes), to interact with national and international institutions for collaborative research, and to provide analytical, diagnostic, consultancy and advisory services to farmers/entrepreneurs, and other agencies.

ASI comprises a number research sections on animal breeding and genetics, animal health, animal biotechnology, animal nutrition, dairy technology, embryo transfer, poultry performance testing, reproductive physiology, and sheep and wool. Facilities include laboratories to undertake applied research in the fields of animal health, nutrition, reproduction, embryo transfer, dairy technology, wool analysis and molecular biology. The research work was done by 25 scientific staff.

The Crop Diseases Research Institute (CDRI), Pakistan, is also part of NARC. It started as a laboratory working on wheat and barley rust. Its current task is to minimize farm level losses through applied and basic research on crop diseases. The institute works with plant breeders to develop disease resistant crop varieties and with farmers to manage crop diseases at field level. CDRI's main research focus areas include genetic variation in crop pathogens of economic importance, identification of sources of resistance against crop pathogens, and integrated crop health management.

CDRI's main research facilities are at NARC in Islamabad where the Institute is carrying out research in the areas of mycology and fungal diseases, phytobacteriology, plant virology and plant nematology. CDRI had a scientific staff strength of 26 persons (8 PhD, 16 MSc, and 2 BSc).

The Coconut Research Institute (CRI) of Sri Lanka was founded in 1929 and is established at Lunuwila, north of Colombo. CRI is part of the Ministry of Plantation Industries (MPI) and is governed by the Coconut Research Board. The mandate of CRI includes developing appropriate crop production and processing technologies for coconut, developing improved coconut-based farming systems, transferring technologies, and conserving coconut genetic resources. CRI is organized in a number of divisions that work on genetics and plant breeding, soils and plant nutrition, crop protection, plant physiology and processing technology.

The institute is staffed by scientific, technical and support staff with research staff comprising 14 PhD, 8 MSc and 18 BSc's on various disciplines. The institute is equipped with laboratories and 320 ha of coconut plantation to conduct field research. CRI owns three coconut seed gardens and four coconut estates to carry out field experiments under diverse soils and climatic conditions.

The National Institute of Animal Husbandry (NIAH), of Vietnam belongs to the Ministry of Agriculture and Rural Development, and was founded in 1969 near Hanoi. NIAH has 12 research units (centers), situated in different regions of Vietnam. NIAH also has 12 research departments that work on the most important disciplines and species (e.g. animal genetics, reproduction, feed analysis, feed processing, biochemistry, poultry, pig, cattle and embryo transfer. NIAH is the leading research institute in the field of animal science in Vietnam. It is responsible for approximately 75% of the research work in the sector. In addition, NIAH provides a number of services to farmers, undertakes work on the conservation of animal genetic resources, and runs significant production facilities. In 1998 NIAH established a joint venture animal feed mill with a French company.

The total number of staff was 635 persons (419 permanent and 216 contracted persons), of which two were professors, six were associate professors, 48 had a PhD, 54 had a Masters degree, and 205 had BSc degrees. The total number of staff with a degree, responsible for the research and service outputs of the institute numbered 315. NIAH is the largest and one of the best funded research institutes in the country. It has been very effective at attracting government and international donor support.

10.5.3 Output analysis

As mentioned, the purpose of the output analysis was not to draw comparisons between institutes in different countries. The only general conclusion that can be drawn relates to the relative importance that each of the institutes attaches to the six different output categories. A simple ranking of the weighted output scores (table 10.6) indicates – contrary to what may be expected from research institutes – that non-research activities play a very important role in the agricultural research organizations. The provision of public services, training activities, and dissemination (technology transfer), often take precedence over what is generally considered to be the core business of research organizations: new agricultural technology and management practices.

The only organization where technology production is the most important activity is NIAH. Here it should be emphasized that NIAH is generally considered to be Vietnam's leading agricultural research institute. It is quite well funded by the government and by donors and has a strong research and technology development agenda. In recent years it has invested heavily in upgrading office and laboratory facilities. In that sense NIAH is atypical of the Vietnam agricultural research system where many organizations are still quite weak in research. NIAH on the other hand has both strong research programs and a long list of commercial ventures.

Trends in output productivity confirm the growing importance of non-research activities for the five institutes. Technology, management and publication outputs are mostly flat over the five year period, while consistent increases can be witnessed for public services. More mixed results but also positive trends are found for training and dissemination outputs.

Table 10.6 Ranking of different output types over the analysis period (1 = highest)[63]

	RIR Indonesia	AIAT Indonesia	ASI Pakistan	CDRI Pakistan	CRI Sri Lanka	NIAH Vietnam
Technology	3	3	3	3	6	1
Management practices	1		5	4	5	5
Publications	5	1	4	2	2	3
Training		4	6	5	3	4
Dissemination	4	2	2	6	4	6
Public Services	2	5	1	1	1	2

There are several explanations for the importance of non-research activities. First, the results of the output assessment may be affected by the fact that technology outputs (e.g. new crop varieties) are often "lumpier" and therefore fewer than others. Second, the results reflect the fact that most of the organizations in the study are seriously underfunded and therefore do not have the means to engage in costly research activities (e.g. those requiring herds of cattle, laboratories and equipment), concentrating in fact on less costly non-research activities. A third factor that plays a role is that for many research institutes international donor support is important and donors tend to finance "development" related activities over research-oriented programs.

A more general conclusion that may be drawn from these findings is that the institutes are changing from being pure research institutes to more broadly oriented technology-based development organizations. The output analysis does not allow any conclusions on how effective the organizations are in managing research processes and providing relevant technologies and other services to farmers. This is the subject of the following section.

[63] As a national commodity research institute RIR does not have a training mandate. In the AIAT analysis, technology and management output categories were combined.

Table 10.7 Key management areas used in OPAS

Management Area	Importance
1. Assessing context and organizational responsiveness	Factors in an organization's external environment (e.g. farmer conditions, government policies, markets, funding levels, partners and competitors) need to be understood in order to plan and produce outputs that are useful, and respond effectively to challenges and opportunities.
2. Planning strategy and goals for the organization	It is important for an organization to periodically review and adjust its directions and goals, given the rapid changes that are characteristic of our times. Strategic planning provides a means of re-positioning the organization in its environment.
3. Selecting organizational objectives and priorities	At the operational level, research objectives and priorities need to reflect development goals and client needs if they are to remain relevant.
4. Planning research projects	As the building blocks of organizational objectives and strategies, projects need to be well planned in terms of their expected outputs, activities, and input requirements.
5. Managing projects and maintaining research quality	Project management and quality assurance/improvement practices are needed to ensure effective research operations and quality of output.
6. Ensuring quality and quantity of scientific, management and technical staff	Adequate numbers of well-qualified staff are a key determinant of organizational performance. Human resource management processes (i.e. staff planning, recruitment, evaluation and training) therefore need to be in place and properly executed.
7. Protecting organizational assets	Effort and attention are needed to protect organizational assets, notably its staff, funds, infrastructure, facilities and equipment, and intellectual property.
8. Coordinating and integrating internal functions, units and activities	Elements of structure and organization (e.g. internal communication, governance, organization structure, terms of reference) need to be reviewed from time to time to ensure organizational coherence and the smooth and efficient running of operations. This management area is often neglected and, as a result, is the cause of many performance problems.
9. Managing linkages and partnerships	A fundamental requirement of research organization management is the dissemination of technology and information to users. In addition, linking up with other actors in the agricultural knowledge and information system (incl. extension, farmer organizations, universities, private sector, international research, etc.) promotes information exchange, collaboration and cost sharing, and ultimately improves the quality and relevance of research.
10. Ensuring effective monitoring, evaluation and reporting	Public research organizations are under increasing pressure to account for their actions and use of resources. Monitoring, evaluation and reporting procedures need to be properly designed (i.e. integrated into project planning and implementation) and periodically reviewed in order to provide useful information for decision-making and accountability.

Source: Peterson, Gijsbers and Wilks, 2003

10.5.4 Management analysis

The ability of an organization to produce useful and relevant outputs largely depends on internal policies, strategies and management practices. The approach used in OPAS is to systematically review a number of key management processes and procedures, and assess the extent to which these are implemented and benefiting the organization. The result is a rapid review of the main drivers of performance through an analysis of management strengths, weaknesses and constraints. Following Szakonyi (1994b) a method was adapted for agricultural research organizations to assess management performance in ten key areas. The method has been refined and validated by research managers in a number of countries.

Discussion of management domains

The ten key management factors used in OPAS to assess the performance of agricultural research organizations are briefly characterized in table 10.7. This selection of management areas was based on a performance assessment system used by government audit agencies and private corporations (Szakonyi, 1994b), and on ISNAR experience in the field of agricultural research management. It was adapted based on feedback from national managers during field-testing of the OPAS. Each management area is reviewed through a set of questions.

Management areas cover processes and procedures that help to keep an organization running, and which are assessed for effectiveness. OPAS uses analytical questions for each management area to determine the extent to which such practices are being implemented and benefiting the organization. These questions need to be examined and in some cases adjusted so that they are appropriate for the organization. One of these sets is presented in Table 10.8. It shows the type of questions to be asked in evaluating management area 4, which is about "planning research projects". The OPAS exercise is implemented through a series of workshop sessions, with participation of a number of selected staff members and preferably with outside facilitation to guide and support the process.

The questions in each set are scored by a representative group of staff from the participating institute. A four-point scale (0–3) is used to measure the degree to which each question or issue is recognized or addressed by managers in the organization, as follows:

0 = management practice not used or realized;
1 = management practice used or realized partially/occasionally/experimentally;
2 = management practice routinely used or realized;
3 = continuous improvements of this management practice under way.

The total score obtained for each management area is divided by the total maximum score (number of questions * 3) to obtain the performance ratio for the management area.

An additional step is to derive constraint ratios – a concept based on the notion that performance at the level of an individual institute is not always under the control of the institute's management. There are cases, where low performance is caused by external, or higher level constraints imposed upon the institute, for example, by government policies and procedures.

Table 10.8 Sample question set for assessing management performance

Management Area 4 - "Planning Research Projects"
1. Has a program framework for component projects been established that provides guidance for researchers during project planning?
2. To what extent is a formal procedure used for planning research projects/activities as components of research programs?
3. To what extent are project priority setting procedures used to determine the relative importance of research activities?
4. To what extent are organization plans (e.g. medium-term plan, corporate plan, strategic plan, etc.) used to guide project design?
5. To what extent are production constraints considered during research project or activity planning?
6. How adequate is the project planning procedure for identifying resource inputs (e.g. staff, supplies, etc.), outputs and indicators of success?
7. To what extent are researchers responsible for project proposal and budget preparation?
8. To what extent are previous research results available to researchers for project planning?

Source: Peterson, Gijsbers and Wilks, 2003

Comparative analysis of strengths and weaknesses in performance

To review the performance of the six institutes in a comparative manner, the scores may be looked at in two different ways: those provided by the institutes during the workshops and as relative scores, related to the average score.

Looking at the raw scores provided in the different national workshops it is evident that the self-scoring by the institutes provides very different results (table 10.9). Some organizations rate their own performance, on average, much higher than others. This may have to do with actual differences in performances, as well as with perceptions of what constitutes good performance. The latter variation should be controlled through systematic checking by the facilitators on whether a certain practice deserves a particularly score (especially when high scores are given for continuous improvement, evidence should be given). Nonetheless it was obvious that the researchers at the RIR were most critical of the performance of their institute (average score of 0.39). This may be related to the fact that, following the restructuring of agricultural research in Indonesia the emphasis (and funding) has shifted to the technology assessment centers (AIAT). The Ungaran AIAT rates its performance significantly higher at 0.55. The highest average score was found at NIAH Vietnam, reflecting the fact that it is generally recognized to be one of the best research institutes in the country. Also it was found throughout the field work that the researchers at NIAH were proud of their work and their institute, finding it more difficult than others to engage in critical reflection. To enable a comparative analysis of relative strengths and weaknesses in performance on the management areas, all average scores were set to one (table 10.10).

Management area 1, assessing context and organizational responsiveness, covers a number of questions, including the effectiveness with which the organization is scanning developments in its external environment (government policies and strategies for the agricultural sector, private sector investment and activities, developments in markets and prices). This management area is clearly considered to be a strength by most organizations, with above average scores by four out of the six.

Table 10.9 Organizational performance assessment of six institutes – absolute scores

Organization	RIR Indonesia	AIAT Indonesia	ASI Pakistan	CDRI Pakistan	CRI Sri Lanka	NIAH Vietnam
1. Assessing context and organizational responsiveness	0.41	0.60	0.66	0.63	0.59	0.66
2. Planning the organization’s strategy	0.42	0.58	0.55	0.64	0.61	0.76
3. Defining the organization’s program objectives and priorities	0.41	0.63	0.50	0.53	0.63	0.61
4. Planning research projects	0.71	0.51	0.58	0.58	0.72	0.66
5. Managing projects and maintaining research quality	0.60	0.53	0.57	0.53	0.61	0.59
6. Ensuring quality and quantity of scientific, management, technical staff	0.26	0.46	0.17	0.15	0.44	0.66
7. Protecting the organization’s assets	0.33	0.30	0.33	0.42	0.53	0.60
8. Coordinating and integrating internal functions, units, and activities	0.33	0.55	0.41	0.59	0.53	0.62
9. Managing dissemination and partnerships	0.15	0.70	0.30	0.67	0.57	0.80
10. Ensuring effective monitoring, evaluation, and reporting	0.27	0.65	0.38	0.57	0.55	0.59
Average score	0.39	0.55	0.45	0.53	0.58	0.66

Management area 2, planning organizational strategy, relates to the longer term direction, objectives and priorities for the organization. Performance indicators in this area include the availability of strategic planning documents and the fact whether these are updated regularly to reflect changing external and internal dynamics. The participation of staff and external stakeholders is an indicator of the extent to which goals and strategies are widely shared. This area is related to the first area and is similarly considered an important strength by all six institutes. The institutes clearly feel they have effective strategies and that, generally they know where they are going. Scores for ASI, CDRI and NIAH are the highest.

Management area 3, defining program objectives and priorities, relates to the ability of research organizations to translate government and organizational policies and strategies, as well as information on markets and prices, and developments in science and technology into a coherent and doable set of research objectives and priorities. The performance in this management area is judged to be average by most institutes with the exception of AIAT, where the high score can be explained by the fact that this new institute has been heavily involved in planning and programming exercises.

Table 10.10 Organizational performance assessment of six institutes – relative scores

Organization	RIR Indonesia	AIAT Indonesia	ASI Pakistan	CDRI Pakistan	CRI Sri Lanka	NIAH Vietnam	Avg.
1. Assessing context and organizational responsiveness	1.05	1.09	1.48	1.19	1.02	1.01	1.14
2. Planning the organization's strategy	1.08	1.05	1.24	1.21	1.06	1.16	1.13
3. Defining the organization's program objectives and priorities	1.05	1.14	1.12	1.00	1.09	0.93	1.06
4. Planning research projects	1.83	0.93	1.30	1.09	1.25	1.01	1.23
5. Managing projects and maintaining research quality	1.54	0.96	1.28	1.00	1.06	0.90	1.12
6. Ensuring quality and quantity of scientific. management., and technical staff	0.67	0.83	0.38	0.28	0.76	1.01	0.66
7. Protecting the organization's assets	0.85	0.54	0.74	0.79	0.92	0.92	0.79
8. Coordinating and integrating internal functions. Units, and activities	0.85	1.00	0.92	1.11	0.92	0.95	0.96
9. Managing dissemination and partnerships	0.39	1.27	0.67	1.26	0.99	1.22	0.97
10. Ensuring effective monitoring, evaluation. and reporting	0.69	1.18	0.85	1.07	0.95	0.90	0.94
Average score	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Management area 4, planning research projects, addresses how objectives and priorities are translated into projects. The relatively low score for AIAT is related to its limited experience in preparing and presenting fundable research projects – due to the fact that part of its staff includes extension workers that have not been trained as researchers. RIR, on the other hand with many years of research experience, lists project planning is its most important strength.

Management area 5, project management and maintaining research quality, is about project implementation. Again it shows high scores for RIR and also for ASI with others presenting average performance.

Management area 6, ensuring quantity and quality of staff in the research, management and technical categories, shows below institute average scores in general. For the two institutes in Pakistan scores are very low, reflecting widespread frustration with staff losses due to budget reductions, ineffective human resource management policies, and a working environment that is generally seen not conducive to good research performance. The highest score in this area goes to NIAH, which reflects that it is a stable institute, where most researchers feel a strong sense of pride about their work, and where the institute has been able to support staff financially through contract research and production activities.

Management area 7, protecting organizational assets, and generally rated as below average with regard to performance, refers both to tangible and intangible assets. Most institutes rate their performance in this area as below institute average. Physical assets such as offices, laboratories and vehicles are often in poor maintenance, while the protection of intellectual property and reputation management are not often addressed.

Management area 8, the coordination of internal units and functions, is important for overall research efficiency. Most organizations rate their performance in this area as average.

Management area 9, the management of technology transfer and partnerships with other actors in the innovation system receives very different scores from the institutes. RIR understandably rates its performance very low as the technology transfer function was essentially moved to the AIAT, which unsurprisingly, scores high on this subject. Most of the organizations include a research and a technology transfer function in their mandate. Of these, ASI reports the lowest scores due to lack of funding for technology transfer activities. In line with expectations NIAH rates this area as one of its key strengths.

Finally, management area 10, the existence of effective monitoring, evaluation and reporting mechanisms, is important for accountability and organizational learning. Performance in this category again shows a mixed picture with low scores for RIR and ASI and relatively high scores for AIAT and CDRI.

Conclusions of the management analysis

1. Overall, there are marked differences in performance between the management areas. Looking at the total average scores the two performance criteria that score lowest are maintaining quality and quantity of staff and protection of organizational assets. The low scores in these areas reflect the declining operational resources allocated to research organizations and in some cases the demoralization of personnel, leading to capable staff leaving for other organization in the non-profit and private sectors.

2. Highest scores are generally reported in two clusters. The first includes areas 1 and 2, which address organizational relevance, responsiveness, forward strategic thinking and the capacity to formulate research objectives and priorities. The second cluster follows from there and addresses the capacity to formulate and manage research projects and to maintain research quality. High scores reflect the fact that most institutes (with the exception of the AIAT) are well established organizations.

3. Below average performance is reported for some management areas that are of key importance for research organizations to be effective players in the agricultural innovation system. These include the internal coordination, but especially the limited capacity to transfer technology, to work effectively with partners, and the low capacity for organizational learning through effective monitoring, evaluation and reporting systems.

10.5.5 Strengths and weaknesses of public agricultural research organizations

In a workshop on performance-based management issues held in Hanoi in June 2003, the participants, who were all senior researchers and research managers from Indonesia, Pakistan, Sri Lanka and Vietnam, were asked 30 questions (see Table 10. 15 at the end of this chapter) about perceived strengths and weaknesses of their organizations and research systems. The questions addressed topics with respect to governance, policy and strategy, external linkages, technology development, acquisition and dissemination, funding mechanisms and other performance related issues. Seventeen out of 18 participants responded to the questions. With the exception of Sri Lanka, where all participants were from a single institute (CRI), participants represented a variety of research institutes as well as central offices in the research system. A five point scale was used, where 1 indicates very ineffective and 5 very effective.

Comparative analysis of strengths and weaknesses

Table 10.11 presents a summary of the most important strengths (those with a score of 3.5 and higher). On average, the organizations consider themselves most effective at their core business of developing new technologies and rate these technologies as quite relevant for the stakeholders. They also rate as effective their accountability to the government (a characteristic of most public sector organizations) and their linkages with other public sector organizations (national and international research and universities). Developing staff knowledge and skills is also considered a strength.

Table 10.11 Key management strengths

Strengths	Indonesia		Pakistan		Sri Lanka		Vietnam		All	
Question	**Q**	Av	**Q**	Av	**Q**	Av	**Q**	Av	**Q**	Av
Developing new technologies	**1**	4.0	**10**	5.0	**29**	3.8	**18**	3.7	**18**	3.7
Relevance to stakeholders	**3**	4.0	**9**	4.8	**9**	3.3	**22**	3.7	**24**	3.6
Linkages with international research	**10**	4.0	**16**	4.5	**18**	3.3	**10**	3.7	**10**	3.3
Linkages with universities	**13**	4.0	**18**	4.5	**22**	3.3	**9**	3.6	**25**	3.3
Accountability to Government	**15**	4.0	**21**	4.5	**23**	3.3	**24**	3.6	**22**	3.2
Addressing biotech biosafety issues	**22**	4.0	**22**	4.5	**24**	3.3	**29**	3.6	**6**	3.1
Improving staff skills	**8**	3.8	**29**	4.5	**6**	3.0	**21**	3.5	**20**	3.1

The most important weakness (table 10.12) identified in all countries is formed by ineffective linkages with the national and the international private sector. The second most important weakness identified concerns the governance of the research system. Other weaknesses include linkages with policy makers and international donors. Most organizations consider farmer participation in research planning and implementation as a weakness. Finally, most organizations do not have effective systems and procedures to assess staff performance, which is a weakness in many public sector organizations.

Table 10.12 Key management weaknesses

Weaknesses	Indonesia		Pakistan		Sri Lanka		Vietnam			All
Question	**Q**	Av	**Q**	Av	**Q**	Av	**Q**	Av	**Q**	Av
Involving external stakeholders	**14**	3.3	**28**	2.5	**26**	2.3	**24**	3.8	**17**	3.0
Linkages with policy makers	**19**	3.3	**11**	2.3	**27**	2.3	**7**	3.5	**15**	2.9
Linkages with national private sector	**23**	3.3	**17**	2.3	**2**	2.0	**12**	3.5	**11**	2.9
Staff performance assessment	**26**	3.3	**1**	2.1	**5**	2.0	**13**	3.5	**5**	2.8
Linkages with international donors	**28**	3.3	**14**	2.1	**14**	2.0	**3**	3.3	**14**	2.8
Governance of research system	**5**	2.5	**2**	1.8	**15**	1.8	**17**	3.3	**2**	2.8
Linkages international private sector	**12**	2.5	**12**	1.4	**12**	1.5	**15**	3.0	**12**	2.2

The main differences between the four countries can be found in table 10.13, which presents top five and bottom five issues in descending (scoring) order for each country.

Country strengths and weaknesses

A number of interesting differences between countries can be highlighted. Indonesia is the only country to rate organizational governance and strategies as a strength. This may be explained by the fact that the research system has been through a comprehensive reorganization and a series of related strategy exercises in recent years.

Linkages with policy makers and with national funding are also considered a strength in Indonesia. In the Indonesian system there is a practice of circulating senior research and management staff between IAARD and the Ministry of Agriculture, which ensures integration and explains the high score. The CRI in Sri Lanka, an institute under the Ministry of Plantation Industries, is not well integrated in national policy as the Council for Agricultural Research Policy (CARP) is under the Ministry of Agriculture, which explains these linkages are mentioned as a weakness. Linkages with policy makers and with national funding are also rated as weaknesses in Vietnam.

Indonesia is the only country that does not rate development of new technologies as a strength. A likely explanation is that the reorganization of the research system, which has separated upstream, national disciplinary and commodity research from downstream, production systems and adaptive research, has not yet resulted in an improved flow of new technology and information. Tasks and responsibilities of the different units in IAARD remain unclear. Whether the reorganization has in fact caused a slowdown in technology delivery is a question for further research.

Table 10.13 Key performance differences

Top 5 Responses (Strengths)

Indonesia	**Pakistan**	**Sri Lanka**	**Vietnam**
Organizational governance	Developing new technologies	Addressing biotechnology and biosafety issues	Linkages International research
Organizational strategy	Accountability to Government	Linkages universities and national research	Linkages universities and national research
Linkages International research	Linkages International research	Developing new technologies	Participation national & international R&D networks
Linkages national funding	Accessing new funding sources	Relevance to stakeholder needs	Developing new technologies
Linkages with policy makers	Relevance to stakeholder needs	Accountability to farmers	Staff knowledge and skills improvement

Bottom 5 Responses (Weaknesses)

Indonesia	**Pakistan**	**Sri Lanka**	**Vietnam**
Accountability to farmers	Participation of external stakeholders	Research system governance	Linkage with private sector
Technology commercialization	Organizational governance	Staff performance assessment	Linkages national funding
Addressing globalization	Linkages international donors	Linkages international donors	Organizational strategy
Staff performance assessment	Research system governance	Linkages with policy makers	Participation of external stakeholders
Linkages private sector	Linkage with private sector	Linkage with private sector	Linkages with policy makers

Sri Lanka is the only country that does not rate linkages with international research as a strength, while rating its links with international donors as a weakness. This can be explained by the fact that the Coconut Research Institute does not work on food crops and that international donors do not fund plantation crop research. Pakistan also lists its links with international donors as a weakness, which reflects many years of international isolation.

Two countries, Sri Lanka and Pakistan consider their research to be relevant to stakeholder needs. CRI Sri Lanka states accountability to farmers as a strength, which is probably because coconut growers form a relatively clear group of clients. Vietnam rates participation of external stakeholders as a weakness, a sign of centralized research system, with strong links to international and national research, but limited involvement of local stakeholders in planning and priority setting.

The main conclusions that can be drawn from the four-country analysis are that:

1. The research organizations in this study consider themselves effective at their core business of developing technologies relevant to farmers and other stakeholders. This belief shows the disconnect between technology producers and technology users. Research organizations usually believe that they develop excellent technology, which is subsequently not picked up by extension organizations and producers. Extension organizations and farmers maintain that research produces results that are not relevant to their needs.

2. The fact that these stakeholders are not effectively involved in research planning and implementation suggests that researchers believe they have other ways of identifying and focusing on farmer needs.

3. The key weakness identified in all four countries is lack of effective linkages with the private sector. Most research organizations appear to be narrowly focused on other public sector organizations, with weak linkages to the private sector, external stakeholders and policy makers. This means they do not contribute very effectively to innovation policies and that they do not influence the policy debate.

5. Although organizations consider themselves effective in technology development, the weakness in research system governance is a serious issue. It means that research is not well coordinated across institutes, and that it is not focused on national priorities.

10.6 Conclusions

Overall conclusions are presented under the headings of governance, finance and performance and the most important challenges for public actors are summarized in table 10.14.

Governance
In all four countries public agricultural research organizations continue to function as public sector bureaucracies with major implications for performance. Reorganizations have taken place including decentralization and restructuring in Indonesia, consolidation in Pakistan en Vietnam, while Sri Lanka is characterized mainly by a continuous reshuffling of government departments. None of these reorganizations have however changed the basic hierarchical pattern of top-down decision-making and an absence of effective horizontal relationships with and outside government bureaucracies. The search for a new paradigm for national agricultural research continues.

While agricultural research in Pakistan and Sri Lanka is in theory under an autonomous council this does not appear to have any impact on actual decision making. In that respect there is no difference with Indonesia where research is under a government agency or Vietnam where it is still part of the Ministry of Agriculture. In fact it can be argued that “autonomous” institutes have the worst of both worlds: on the one hand no real autonomy and on the other there is a distance to the Ministries of Agriculture, where key decisions are made.

Governance problems are a having major impact on staff morale and staff attrition in Pakistan and on research institutes under the Department of Agriculture in Sri Lanka. In Vietnam staff morale is much higher, partly because of the opportunities to obtain additional income and more generally because researchers are well respected. In Indonesia the reorganization of 1995 has had a negative effect on staff morale, but few people actually leave government service, amongst others because of secondary benefits.

Table 10.14 Summary: main challenges for public research organizations

Challenges for public actors	Indonesia	Pakistan	Sri Lanka	Vietnam
Linkages (with policy, private sector, clients)	M	H	H	L
Governance: centralized, top-down decision-making	H	H	H	H
Lack of coordination / fragmentation of research effort	M	H	H	L
Funding levels (operational funding for researchers)	M	H	H	L
Staff issues (staff quality, morale, attrition)	M	H	H	L
Improve relevance of technologies for client needs	H	H	H	M

Finance
Public sector research continues to be the core actor in agricultural innovation with over 90% of agricultural research expenditures in all four countries. Budgets have grown in absolute terms in most countries, but declined as a percentage of AgGDP. Operational budgets (funding per researcher) have been most under pressure. The only exception is Vietnam where government budgets (and donor support) for research have grown rapidly.

Donors have a considerable influence on the research systems and have been behind major reorganizations in Indonesia and Sri Lanka. By concentrating on research operations, relatively small amounts of donor funding have skewed programs and priorities for the research system. Especially, donors have emphasized the need to decentralize research and to contribute to poverty alleviation. While some programs have been very successful (support for development of new varieties, IPM) attempts at structural reform have not succeeded.

Performance
Most research organizations have diversified beyond their core task of technology development and give considerable attention to non-research tasks such as training, dissemination and the provision of public services. At the same time the services provided by the research organizations are often seen as not relevant to the needs of stakeholders.

From different sources (reports, interviews, and performance assessments) a consistent picture emerges that the most important problem faced by agricultural research organizations is establishing and maintaining effective linkages with other actors in the innovation system – farmers, agribusiness, but also government policy makers. The exception is Vietnam where research organizations have a very different background with close linkages to the productive sector. The absence (until recently) of a private sector supplying inputs, as well as a government policy to encourage researchers to do consultancy work, has further strengthened the links between research and stakeholders.

Table 10.15 Questionnaire responses (1-5 scale, with 5 as highest)

All	IN	PAK	SL	VN	Q. Nr	Questions
N =17	4	5	4	4		
3.0	4.0	2.1	2.3	3.8	1	How effective, in your opinion is the governance of your organization?
2.8	3.5	1.8	2.0	4.0	2	How effective is the governance of your research system (national)
3.1	4.0	2.5	2.8	3.3	3	How effective are the present strategies used by your organization?
3.3	3.5	2.9	2.5	4.3	4	How effective is your organization in responding to changes in the external environment?
2.8	2.5	2.5	2.0	4.3	5	How effective is the staff performance and assessment system at your organization/system?
3.3	3.3	3.1	3.0	4.0	6	How effective are the linkages of your organization with farmers?
3.1	3.5	2.6	2.8	3.5	7	How effective are the linkages of your organization with farmer organizations?
3.1	3.8	2.8	2.3	3.8	8	How effective are the linkages of your organization with extension?
3.6	3.8	2.9	3.3	4.8	9	How effective are your organization’s linkages with universities and other national research organizations?
3.7	4.0	3.3	2.5	5.0	10	How effective are the linkages of your organization with international research organizations?
2.9	3.3	2.3	2.5	3.8	11	How effective are the linkages of your organization with the private sector (national)?
2.2	2.5	1.4	1.5	3.5	12	How effective are the linkages of your organization with the private sector (international)?
3.3	4.0	2.9	2.8	3.5	13	How effective are the linkages of your organization with national funding agencies?
2.8	3.3	2.1	2.0	4.0	14	How effective are the linkages of your organization with international donors?
2.9	4.0	3.0	1.8	3.0	15	How effective are the linkages of your organization with policy makers?

Table 10.15 Questionnaire responses – continued

All	IN	PAK	SL	VN	Q. Nr	Questions
3.3	3.7	2.7	2.5	4.5	16	How effectively is your organization participating in national and international R&D networks?
3.0	3.8	2.3	2.8	3.3	17	How effective is your organization in involving external stakeholders in planning and other activities?
3.7	3.5	3.7	3.3	4.5	18	How effective is your organization in the development of new technologies?
3.3	3.3	2.9	3.0	4.3	19	How effective is your organization in transferring technologies to farmers?
3.3	3.5	3.1	2.3	4.3	20	How effective is your organization in obtaining new technologies from advanced research organizations?
3.5	3.8	3.0	2.8	4.5	21	How effective is your organization in improving the knowledge and skills of its staff?
3.7	4.0	3.2	3.3	4.5	22	How relevant and responsive is your organization to the needs of its stakeholders?
3.4	3.3	2.9	3.3	4.3	23	How effective is your organization's accountability to farmers?
3.6	3.8	3.6	3.3	3.8	24	How effective is your organization's accountability to the Govt.?
3.4	3.8	3.3	2.3	4.3	25	How effective is your organization in accessing new sources of funding?
3.1	3.3	2.8	2.3	4.3	26	How effective is your organization in commercializing its technology?
3.1	3.8	2.5	2.3	4.3	27	How effective is your organization in addressing research policy issues?
3.0	3.3	2.5	2.5	4.0	28	How well is your organization dealing with the challenges of globalization?
3.6	3.5	2.8	3.8	4.5	29	How well is your organization addressing issues related to biotechnology and biosafety?
3.4	3.8	3.0	2.8	4.3	30	How effective is your organization in attracting new sources of funding?
3.2	**3.5**	**2.8**	**2.6**	**4.1**		**< Average**

11. Private agricultural innovation actors

11.1 Introduction

Innovation, throughout the history of agriculture, has mainly been a private activity, undertaken by individual farmers who developed improved crops, livestock breeds and farm management practices. Since the 19th Century more formal institutional arrangements emerged both in the form of agricultural universities, publicly funded experiment stations and private companies that sought to commercialize new seeds and planting material, machinery, and agro-chemicals.

This chapter consists of two main parts. The first discusses private agricultural research. It analyzes the roles of private agricultural research in agricultural innovation (section 11.2), followed by a discussion of private agricultural research and innovation activities at different levels – globally (11.3), in Asia (11.4), and in four countries (11.5). A more in-depth look at the activities of private innovation actors in Indonesia is presented in section 11.6. The second part of this chapter focuses on the emerging role of supermarkets in inducing innovations in the agri-food chains in Asia and in the four countries of this study (11.7). The chapter closes with a note on the role of NGOs (11.8) and conclusions (11.9).

11.2 Roles of the private sector in research and innovation

For the private sector to be interested in investing research, the results of the research effort have to be private goods which are appropriable (i.e. where benefits accrue to the investor). To achieve appropriability the use of a good has to be excludable, which means those who have not invested in its production can be excluded from consuming it. Excludability can be inherent in the technology or it can be achieved through protecting intellectual property.

Agricultural research produces knowledge that may be stand-alone (disembodied), or that may be embodied in products (e.g. seeds, chemicals). Knowledge that is not embodied is in principle a public good – because it is non-excludable as well as non-rival (i.e. consumption by one person does not diminish its availability to others). This would suggest a tendency for the private sector to underinvest in research, which in turn creates a (market failure) role for public sector investment. As a result, in agriculture the public sector has traditionally played a key role in research and innovation and the private sector has played a smaller role, focusing on products and technologies that cannot be easily copied or reproduced. But this picture is changing for a number of reasons. First, pure public goods are rare and if they do exist they are often not directly relevant to agricultural innovation[64]. Second, tightening of IPR regimes causes a shift from public to private goods. And third, as agriculture becomes more complex, much of the disembodied knowledge is actually tacit knowledge about how to do things

[64] Scientific outputs in the form of publications that are often mentioned as examples of “international public goods” are really “club goods”, available to those who have access to the literature and the educational background to benefit from reading them.

which is not easily transferred to other people, products or situations. The advanced logistics used by supermarket chains is good example of this.

Pray and Umali-Deininger (1998) present five developments that have caused a shift in attention to the role of the private sector in agricultural research. These include: declining funding levels of public research in many countries[65]; “institutional failures” due to weak public management and bureaucratic inefficiencies in public sector agricultural research; growing importance of intellectual property rights worldwide; privatization of R&D and the encouragement of competition among research suppliers; and the increased commercialization and competition in global agriculture.

The question that Pray and Umali-Deininger (1998) then ask about private agricultural research is whether it will it will fill the gap that is created by underperforming public research systems. They discuss from a theoretical and empirical perspective whether, and how the private sector is likely to make up for the decline in public sector agricultural research activities and identify those areas where the private for-profit sector could play a role. As potential profitability is the main determinant of private investment in agricultural research, it tends to focus on countries with large markets for modern inputs and products for which returns to research can be appropriated. Government policies that strengthen IPR and an open economy, which allows easy importing of technologies are also of key importance. On the other hand, the private sector is unlikely to enter into agricultural research in small markets and to engage in activities that are likely to produce non-excludable public goods. Also, the presence of a large public sector agricultural research system may crowd out private investment. The major challenge is to identify complementarities between public and private sector research and to develop effective arrangements for public and private research to cooperate in an effective manner.

Naseem et al. (2006) provide more detail on institutional issues in their discussion of the key determinants of private sector agricultural research including market size and structure (demand), appropriability of research results and property rights, institutions and governance, public sector research, availability of new technology as a result of research breakthroughs, and the specific characteristics of the firm. The authors analyze a number of push and pull mechanisms that stimulate private R&D. Push mechanisms promote research by reducing costs to firms of developing new technologies. Pull mechanisms promote research by creating attractive markets for research results, especially innovative products and services. Important push mechanisms are:

- Public sector research. Whether strong public research promotes private sector research depends on whether the two are complements or substitutes. In the latter case public research may crowd out private research;
- Fiscal policies aim at reducing the cost of research to firms. In developed countries tax credits have been widely used as an instrument to promote private R&D, though their use in developing countries is limited. Competitive research open to the private sector are another instrument to reduce research costs to firms;

[65] The evidence of declining public research investment in agricultural research is actually mixed as reported in section 11.1 and applies mostly to developed countries and to Africa.

- Regulation: an effective regulatory framework for new technologies helps to instill confidence with consumers, and it reduces uncertainty for firms. Evidence as to whether regulation supports research is mixed: when too tight it may be a disincentive to research;
- Research infrastructure: the establishment of research parks and zones can reduce the cost of research and support linkages between universities and companies;
- Public-private partnerships may promote private R&D, though the evidence is mixed as partnerships may involve high transaction costs;
- Intermediation and brokering may help overcome barrier to private investment.

Pull mechanisms aim to create larger and more stable markets. The attractiveness of pull mechanisms for policy makers is that, unlike push mechanisms they do not require significant government expenditure.

- IPR is generally seen as the most powerful mechanism to provide incentives to research. IPR includes patents, plant breeders' rights and technological means to prevent multiplication or copying such as hybrid seed technology;
- Market and trade liberalization may encourage FDI, though it may also lead to centralization of R&D;
- Advance purchase commitments by governments aim to create a market where no effective demand is perceived to exist. This model is being used in the development of drugs for tropical diseases, but is not widely used in agriculture. Its effectiveness depends largely on the credibility of the commitment;
- Rewards and prizes may also stimulate research.

The discussion in the (agro-economic) literature on the role of the private sector in agricultural research is discussed in more detail in the following section.

11.3 Global private agricultural research investments

Worldwide, most research is done by the private sector. The UNESCO Science Report 2005 indicates that industry increasingly dominates R&D funding, especially in the developed world. In the USA, Europe and in Japan industry accounts for typically between 65 and 75% of Gross Expenditure on R&D (GERD). At the same time the share of government funding has decreased significantly – in the USA for example from 40% of GERD in the 1950s to 10% in 2000.

Private sector research overall tends to be concentrated in a relatively small number of MNEs. UNCTAD in its World Investment Report (2005) indicates that:

> "…with $310 billion spent in 2002 […] the 700 largest R&D spending firms of the world – of which at least 98% are TNCs – accounted for close to half (46%) of the world's total R&D expenditure and more than two-thirds (69%) of the world's business R&D."

Similarly, global research expenditures have been highly concentrated in North America (37.0%), Europe (27.3%) and Japan (12.8%), with 77.1 % of total world R&D expenditure in the “triad”. The share of developing countries is growing, but from a low base and mostly as result of increased research spending in Asia, where a number of governments have declared science and technology a strategic priority (e.g. China, India, Korea, Singapore, Malaysia and Vietnam).

For agricultural research, the picture has been different, with a relatively large share of R&D work done in developing countries. For the early 1990s Roseboom (2002) reports that most agricultural R&D took place in developing countries – 54% vs. 46% in developed countries. Table 10.2 in the previous chapter showed total agricultural research expenditures of almost 14 billion international dollars (or 37.5%) in developing countries and almost 23 billion dollars (or 62.5%) in developed countries. And whereas private agricultural research accounts for over half (13 billion out of 23 billion dollars, or 55%) of total agricultural research in developed countries, an overwhelming share (almost 94%) of agricultural research in developing countries is funded by the public sector. Worldwide, private sector agricultural research accounted for almost 37% of the total, but in developing countries the share of the private sector is a tiny 6%.

11.4 Private agricultural research in Asia

Private sector research in Asia has a long history. Throughout the 19th and a large part of the 20th Century agricultural research was dominated by the plantation crop sector, which was privately owned in colonial times and in the early post independence years. Main plantation crops were oil palm, rubber, coffee, tea, sugar and tobacco. After independence in de middle of the 20th Century many countries, including Indonesia and Sri Lanka nationalized the plantation sector, after which research became a government responsibility. Vietnam introduced collective forms of agriculture in the North in the 1950s and in the South after reunification in the 1970s, returning responsibility for production to farmers after the introduction of the Doi Moi reforms of 1985. In Pakistan land distribution is highly unequal, but the country does not have a traditional plantation crop sector and even in the cotton production sector there are only a few large farms of over 60 hectares (World Bank 2006c).

Little quantitative information is available about private research expenditures. For the Asia-Pacific region in 2000, Pardey et al. (table 10.2) report private agricultural research expenditures of 663 million international dollars, or 8% of total agricultural research expenditures amounting to 8.1 billion international dollars.

Based on a series of case studies[66] Pray and Fuglie (2002) present a number of “stylized facts” about agricultural research by private companies in Asia:

- Private sector research has increased since the 1980s;
- Private sector research intensity remains very low at less than 0.01% of agricultural value added;

[66] The cases include India, Pakistan, Thailand, Indonesia, Malaysia, the Philippines and China.

- Private agricultural research remains small in comparison to public agricultural research at 10-20%;
- Foreign firms play an important role in agricultural research, although there is quite a variation between countries. In Indonesia 58% of private agricultural R&D is done by foreign firms while in Pakistan it amounts to 31%;
- Private agricultural R&D is concentrated in a few sectors: agrochemicals, pharmaceuticals, machinery and food processing;
- Private agricultural R&D is complementary to public R&D, which traditionally focused on improved varieties and cultural practices, mainly for food crops;
- The public research system is an important source of researchers for private R&D.

Private agricultural research in Asia remains very small compared to the publicly funded effort. This holds for both the estimate of 10-20% from the Pray and Fuglie case studies, and the more recent estimate of 8% by Pardey et al. that is based on a broad set of data. The following paragraphs look in more detail at private agricultural research in Indonesia, Pakistan, Sri Lanka and Vietnam based on published data and on the basis of 30 interviews held with and questionnaires returned by companies in these countries.

11.5 Private agricultural research and innovation in four countries

Information on private agricultural R&D investment at country level is much more limited than for publicly funded R&D. The Pray and Fuglie (2002) publication provides information on Indonesia and Pakistan, while the Agricultural Science and Technology Indicators (ASTI) project (Stads et al. 2005 and Stads and Hai 2006) provides information on private sector agricultural R&D in Sri Lanka and Vietnam.

11.5.1 Indonesia

In Indonesia the environment and conditions for private agricultural research have been relatively favorable. The country presents a large market and attracted billions of dollars of FDI in the period preceding the Asian financial crisis of 1997. Under the Suharto government agriculture had a very high priority, domestic commodity prices were considerably higher than world market prices to encourage local production, imports of agricultural commodities and food products were strictly regulated, large investments were made in infrastructure (irrigation, access roads and fertilizer factories), inputs were subsidized and the public sector and international donors strongly supported research and extension.

Much has changed since the arrival of democracy in Indonesia, but high prices, at least for rice, continue to be a cornerstone of government food policy. Since 2004 there has been an almost complete ban on the import of rice which has caused domestic rice prices to soar above world market prices (Timmer 2006). While high prices promote agricultural production and support the incomes of rural rice growers such high prices have significant negative effects as well. First, they limit the need for innovation in rice production practices. Second, artificially high rice prices are a disincentive to the diversification of the agricultural economy away from rice. High value commodities such as fruits and vegetables provide higher incomes to farmers and are led by consumer demand rather than producer price support measures.

For Indonesia Pray and Fuglie (2002) and Fuglie and Piggot (2006) estimate that private funding for agricultural research and development has increased from $6.6 to $18.2 million between 1985 and 1996 (constant 1999 dollars). This amounted to 6.5% of the total agricultural research layout of $278 million in the second half of the 1990s. Pray and Fuglie (2002) indicate that agricultural R&D was undertaken by 19 companies[67] and concentrated in a few sectors: the seed industry (plant breeding), the agro-chemical industry, private plantations[68], livestock (poultry), and biotechnology. Not included in their report are two groups of companies that are increasingly important in agricultural innovation: food companies and supermarkets.

11.5.2 Pakistan

For Pakistan the conditions for agricultural R&D have not been very conducive. Until 1998 government policies toward the agricultural sector have been unfavorable with low producer prices for the most important agricultural commodities: cotton, rice and wheat (Ahmad and Nagy 2002). Lack of IPR protection and low enforcement potential is limiting the involvement of international seed companies, which affects the cotton sector in particular – unlike for food crops there is little public research investment in cotton. Since 1998 the government has pursued a policy of opening up the economy and attracting foreign investment. The agricultural economy has grown since then, but FDI has been depressed as a result of uncertainty following the nuclear test of 1998 and the terrorism threat since 2001.

Ahmad and Nagy (2002), on the basis of questionnaires returned by 159 companies (and which, according to the authors, includes 95% of all firms that undertake private agricultural research), conclude that most research by companies is of an adaptive nature (i.e. adapting technology to local conditions) and functioned as an adjunct to the main business of selling inputs or processed products. The firms conducting research fall into two main types: those providing agricultural inputs (adaptation of machinery, agronomic field trials, varietal testing, testing new animal breeds and feed ingredients) and agricultural processing firms (product development, adaptation to local tastes, processing, etc.). Data on research expenditures were not provided by the firms surveyed, but authors estimate based on the numbers of researchers employed that private agricultural research expenditure of $5-6 million represent around 20% of the total research expenditure of $25 million. This figure appears to be quite high compared to other estimates of Asian countries, which indicate private investments in the range of 4-10% of total agricultural research. The discrepancy can be explained on the one hand by the fact that Pakistan's public agricultural research expenditure is quite low in comparison to other countries in Asia. On the other hand, converting numbers of researchers into expenditure figures may overestimate research expenditures as in many companies that do adaptive research exclusively, research staff is likely to be involved in a range of non-research activities as well. There is also the possibility that companies refer to a number of routine testing activities and similar as "research".

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[67] It is not clear from the report which of the companies mentioned in the tables are the R&D performers.
[68] Since the nationalization of the plantation sector in the 1960s a few large private oil palm plantations have been established since the 1980s

11.5.3 Sri Lanka

The external conditions for private agricultural research in Sri Lanka do not support private sector agricultural research investments. Although the regulatory environment is more helpful to investment than that of other countries, there are factors that limit the potential benefits for private investors in agricultural R&D. To start with, the size of the domestic market is quite small, but perhaps more important is the fact that the agricultural economy is highly regulated and characterized by important structural rigidities, especially in the land market, where land farmed to rice cannot be put to other more productive uses (ADB 2007).

As a result, privately performed agricultural R&D is very limited accounting for less than 1% of staff and expenditures. Private agricultural R&D is negligible, with only one company identified as undertaking agricultural R&D (Stads et al. 2005). This company, CIC Agribusiness of Colombo, produces high quality planting material (flowers and vegetables), using both traditional and tissue culture technologies. The company also provides a number of other services included soil analytical services, private extension for perennial crops and contract management services (interview with Fazal Sultanbawa, Director R&D, CIC, 2005). Interviews and questionnaires returned by five other companies indicate that none of these perform any significant R&D activities.

11.5.4 Vietnam

Vietnam’s (agricultural) economy is the rising star of Southeast Asia. The country has a large and growing market, which has attracted very substantial amounts of FDI since 2000. Government investment in public agricultural research has increased rapidly in recent years. However, Stads and Hai (2006) find that private agricultural R&D remains minimal, as many enterprises remain in public hands. The authors identified one agricultural company investing rather heavily in R&D: East-West Seeds, a Dutch company established in a number of countries in Southeast Asia, which concentrates on vegetable seeds. East-West Seeds has developed high yielding and disease tolerant varieties of cabbage, bitter gourd, kankong, eggplant and a number of other vegetables. The company employs 15 R&D staff in Vietnam.

Interviews with a number of companies in Vietnam confirmed that very little research is actually taking place. Cargill Vietnam has three feedmills in the country with an investment of USD 30 million. Cargill does not do any research in Vietnam but relies on advanced, computerized systems of quality control developed in the home country. And for more advanced R&D services it relies on direct support from its headquarters in the USA (where it employs more than 50 PhDs in research in its innovation center). The feedmills have small labs for analysis (employing 2-4 staff) to keep costs low. Cargill does work in transferring its technology: since 1996 it has trained more than 25,000 distributors and agents. Another company, Monsanto, has a representative office in Ho Chi Minh City and does no research locally. Instead it relies on a regional SE Asia research facility based in Thailand. Unilever-Bestfoods also does not do any research in Vietnam. But as a consumer products company it sees a need to optimize its supply chain and to adapt its products to local tastes. Its strategy has been to establish relationships with local research and technology organizations such as the Post Harvest Technology Institute (PHTI), which also has production facilities, to upgrade the quality of supply of raw materials.

11.5.5 Conclusions on private agricultural R&D

1. Private agricultural R&D in Asia remains very limited – based on interviews and secondary information reported above, significantly lower than the 10-20% of total research effort as reported by some sources (e.g. Pray and Fuglie 2002).

2. Contrary to what is often reported, this study found no evidence of significant growth in private agricultural R&D in the four countries studied. Private companies expand their activities, but centralize research activities as much as possible at their home base, or at an Asian R&D hub. This is possible as they concentrate on technology packages that are broadly applicable in wide range of production systems.

3. Research conducted or commissioned by private companies is of a highly adaptive nature. There are very few linkages between private and public research institutes. The few that exist are of a one-off contractual nature.

11.6 Private innovation actors in Indonesia: an in-depth look

Of the four countries studied Indonesia has long been the most attractive market for private agricultural research because of its large market size, and supportive government policies. A more in-depth review of private agricultural research actors in Indonesia is based on interviews held with 14 companies in the agri-food sector. Table 11.1 lists the names of the companies, their core business and the size of their research departments. The companies interviewed cover a broad range of activities: seed production (4 companies), food (3), agricultural machinery (2), animal feed, poultry and meat (2), hydroponics equipment (1), vegetable production (1) and agribusiness and trading (1).

The R&D effort of these companies in terms of number of staff employed differs markedly between these companies. As in Vietnam, East-West Seeds with 180 research staff is a major actor: a research based international company (originally Dutch, but with headquarters in Thailand) that has successfully created a market for high quality vegetable seeds in a number of Asian countries. Another multinational seed company, Dow Agroscience Indonesia employs only a few R&D staff to support product marketing. Like most subsidiaries of multinationals it relies on research facilities outside Indonesia for its new technology. Monsanto, an important seed and biotechnology company employs researchers in its seed business (multilocation testing of germplasm), but also to do research on its transgenic Ballguard cotton variety for which the company received a limited release permit from the National Biosafety Committee. This allows production of transgenic cotton in a number of districts in Sulawesi. The purpose of the research was to convince the regulatory authorities of the safety of growing Ballguard cotton, based on measurement of geneflows, measurement of impact on non-target crops, impact on soil ecology, socio-economic impact and development of insect resistance[69].

[69] Monsanto complains that it had to convince the Ministry above and beyond the legal requirements, which has cost the company Rp 1 billion per year ($100,000) at current prices. Still the company has been given only a “limited release” permit – something that the regulations do not provide.

Table 11.1 Indonesian companies interviewed

Company name	Core business	Home base	No. of R&D staff
Dupont-Pioneer Indonesia	Seed	USA	3
PT Yanmar Indonesia (Yamindo)	agricultural machinery	Indonesia	20
PT General Agromesin Lestari	agricultural machinery	Indonesia	0
Nestlé Indonesia	Food	Switzerland	0
PT Nutricia Indonesia	Food	Netherlands	0
East-West Seeds	vegetable seeds	Thailand / Netherlands	180
Charoen Phokpand Group Indonesia	poultry, animal feed	Thailand	30
PT Indofood	Food	Indonesia	67
PT Saung Mirwan	vegetable growers	Indonesia	0
PT Joro	horticulture, hydroponics equipment	Indonesia	5
Monsanto Indonesia	seed / biotech	USA	25
Dow Agrosciences Indonesia	agrochemicals / seed	USA	5
PT Kebun	agribusiness / trading	Indonesia	6
PT Japfa Comfeed	animal feed / poultry	Indonesia	20

Other multinationals reported not doing any research at all in Indonesia. These home base exploiting companies derive their performance from centrally developed technologies and standards, which they bring to a number of markets around the world. The backbone of Nestlé Indonesia is the milk powder business, which it started in 1975. Now it deals with 28,000 farmers, through 30 cooperatives in the collection of fresh milk all in East Java. Nestlé receives 500 tons of fresh milk/day, which represents 50% of national milk production, making Nestlé the biggest milk producer. The key issue is quality control of fresh milk, but this does not require R&D. No research is done or needed in Indonesia as spraydrying technology to produce milk powder is basically old technology. Nestlé's R&D is concentrated in Singapore, and Lausanne where more advanced tests are done (e.g. checking for GMO content of soybean). Similarly, PT Nutricia does not do any research in Indonesia. Its core activity is the production of infant formula milk powder based on imported and local ingredients and which only requires basic quality control in Indonesia. Any problems requiring research support are referred to central R&D research facilities in the Netherlands.

In contrast, a major nationally owned food company such as Indofood does require its own R&D facilities as it cannot rely on R&D facilities outside the country. Nationally owned food companies are also more likely than the MNEs to develop their own local brands which require product development and which is often supported by some R&D.

The Indonesian animal feed and poultry sector have seen rapid transformation since policy measures to protect small producers were abolished in 1993. The Thai multinational Charoen

Phokpand (CP) Group established itself in Indonesia in 1972 as a 100% foreign owned company (PMA – Penamanan Modal Asing). Its core business is animal feed, but it has diversified into crop production (maize, fruits), seed, animal production (day old chicks, broilers) and processing. CP Group covers the entire chain in an integrated manner: from maize seed to spicy chicken wings sold in fast food outlets. R&D is directly linked to quality control and to new product development for the Indonesian market (including halal food requirements). PT Japfa Comfeed is the second integrated feed and animal production company in Indonesia in turnover after CP Group. Its R&D is mainly linked to quality control, especially to ensure compliance with ISO and HACCP standards, which are essential if the company is to succeed in its plans to export meat products internationally.

Of the two agricultural machinery companies PT Yanmar is a subsidiary of a Japanese company. Its engineering staff is mainly involved in the adaptation of Japanese designed machinery to local conditions. Agromesin Lestari follows a different strategy: it focuses on low cost machinery and equipment manufactured in China from standard components. The company does not have an R&D unit. PT Joro is an important supplier equipment and input to the vegetable production sector, with a focus on hydroponics production of vegetables. It has a small R&D lab for adaptation of equipment and practices to local circumstances.

PT Kebun is an agribusiness and trading company. The bulk of its effort is on spice trading, which accounts for 80% of its turnover. (It has offices in several countries including the Netherlands). It has an R&D department of 6 staff (based in Medan, S. Sulawesi, E. Java and Jakarta). The role of research is to answer technology related questions of the production department (e.g. fertilizer recommendations). Research focuses on agronomy, packaging and transportation. Other innovations include the use of production contracts, close supervision and advice to farmers in the vicinity of the company's own farms to ensure that the considerable investment in horticultural production does earn a return both to farmers and to PT Kebun. Finally, the Saung Mirwan Company is an important fresh vegetable supplier to the Jakarta market, concentrating on high-quality, non-traditional products such as paprika, cucumber, and tomato. The company has also diversified into flowers. The company takes a learning-by-doing approach and does not have an R&D department.

If the research effort of private sector companies in Indonesia is limited, perhaps they rely on research subcontracted to national public research institutes, such as the institutes of the Indonesian Agency for Agricultural Research and Development (IAARD)? According to the interviews this is not the case. With two exceptions, where external funding has forged a relationship between the company and the Research Institute for Vegetables (in Lembang), the companies report an almost complete lack of interaction with the public research system. The most important reasons mentioned for not maintaining relationships with research institutes include the different cultures of public and private sectors, the limited relevance of public sector research and technology, the ineffectiveness of government agencies with regard to intellectual property rights, and the availability of technological support from company headquarters. For Monsanto a complicating factor in its relationship with IAARD is that this organization is at the same time a research competitor and, through its Biosafety Committee, a regulator.

Box 11.1. Multinationals, universities and local value chains

Clay (2006) reports on a joint research project between Oxfam, Novib and Unilever Indonesia (UI) to assess the impact of UI on poverty in Indonesia. The report presents a case study on UI's evolving relationships with local producers of black soybean, a key ingredient of Kecap Bango. Kecap Bango is a niche product made from fermented black soybean and coconut sugar (most kecap is made from yellow soybeans). The brand was acquired by UI in 2001, based on its strong brand name and expected growth potential. For UI Kecap Bango is small with around 1.5% of company turnover but it is a very labor intensive product, involving close to 14,000 producers and processors. Since acquiring the brand, production has increased from 4,000 to 21,000 MT in 2004. This rapid growth created a bottleneck in the production of black soybean which is a highly specialized product.

In 2001 UI purchased all black soybeans from traders, but the growth in demand required UI to create an alternative supply channel in order to increase (reliability of) supplies, improve quality and reduce costs. UI decided to introduce a contract farming scheme with a number of key elements. First, new black soybean varieties were developed by Gajah Mada University (GMU) of Yogyakarta. GMU and UI worked together to develop and improve the quality of soybean seeds, develop certified seed sources, and identify more reliable production methods GMU has meanwhile introduced the new seed and technology package to hundreds of growers. Second, institutional changes were needed to ensure increased production through the provision of credit, by guaranteeing farmers purchase of the product at a contracted price.

The benefits for farmers consist of higher prices (10-15% mainly because of a reduced role of middlemen) and an assured marketing channel at an agreed price. For UI the benefits are reliable, high quality supplies of an ingredient where demand is higher than supply.

Problems for farmers (at least initially) were relatively high rates of rejects due to low soybean quality (prompting a need for extension of loan periods), the loss of flexibility in selling their produce and the possibility of becoming over-dependent on an exclusive buyer. For UI the new system has much higher transaction cost than simply purchasing soybean from traders – it needs to get deeply involved in technology, certification, credit and contract farming – which is why UI will continue also to buy from traders.

Source: Clay, J. 2006. Exploring the links between international business and poverty reduction: A case study of Unilever in Indonesia.

Four out of 14 companies maintain relationships with universities. An example of University – MNE cooperation is presented in Box 11.1. Companies find universities more flexible than IAARD. This relates mainly to the flexibility of university researchers in undertaking consultancies for private companies. Unless external funding is available to support joint R&D relationships between the public and the private sector tend to be of a contractual, one-off nature.

In conclusion, and taking into account the small number of companies interviewed, a number of observations may be made. First, multinational companies interviewed are of the home base exploiting type and rely on centralized R&D functions in the home country. Global exploitation of advanced technology and logistics forms the basis for their performance.

Second, large national companies appear to be more involved in research than international ones, which can be explained by the fact that they cannot rely on external research backup and support.

Third, R&D is mainly linked to local problem solving, and product development, with a focus on adaptation to local circumstances (seed, consumer goods). The one clear exception is East West Seeds which has made a strategic choice to become a market leader in hybrid tropical vegetables, a product group that has not received much attention from public sector research.

Fourth, linkages between the private sector and public sector research institutes are quite limited for a number of reasons. Linkages with universities appear to be more appealing to companies than relationships with the public agricultural research institutes. Linkages are of a one-off type contractual nature and based on companies' needs for flexibility – companies do not appear to be interested in longer term relationships unless other (often public) organizations support the establishment of partnerships.

11.7 Supermarkets and the new supply chain

Supermarkets are very different types of organizations than the life science and agro-chemicals companies reviewed above. They are not usually involved in doing research – so why discuss them in relation to agricultural innovation? Supermarkets, it is argued are rapidly spreading in developing countries and they are instrumental in bringing about changes in food production, marketing and processing that affect the value chain in a profound manner, and that introduce a number of technical, institutional and organizational innovations at different stages in the supply chain. It is not only the growth in number of supermarkets, their market share and the geographical dissemination that counts, but probably more important are the changes that the supermarket revolution has caused in the way supply chains are governed.

Supermarkets have emerged as important innovation actors because they are caught in between the demands of consumers (for products that are fresh, safe, high quality, available year round, and uniform in size and taste) and the inability of the traditional producers and the traditional wholesale market (spotmarkets) to meet those challenges. To resolve this problem, supermarkets needed to get involved in a direct manner.

The recent phenomenon of the rapid rise of supermarkets in developing countries was introduced in chapter 9. A large number of studies have appeared since 2002 that document the spread of supermarkets in developing countries (Reardon et al. 2004a), in Eastern Europe (Dries et al. 2004), in Africa (Weatherspoon and Reardon 2003), and in Latin America and Asia. (Reardon et al. 2004b). Major factors explaining supermarket diffusion include urbanization, growing middle class incomes, increased value of women's time, and the diffusion of refrigerators (Reardon et al. 2004a). Changes to more western diets are another important factor (Pingali 2004). Market liberalization, availability of FDI, and saturated home markets made developing country markets increasingly attractive for international retail chains. Several sources (Traill 2006, Natawidjaja et al. 2006) suggest that the key drivers behind the rapid diffusion of supermarkets have been FDI and the opening up of retail markets.

While a small number of domestic supermarkets have been in operation in many Asian countries for many years (mainly catering to the needs of a small upper class), rapid growth in Asia started in the second half of the 1990s. Reardon et al. (2004b) quote market research data from AC Nielsen that the supermarket share of the retail market for food (excluding fresh food) in Southeast Asia and East Asia in 2004 was 33% and 63% respectively. Supermarkets, in other words are no longer places where only rich people shop, but in the past 10 years they have spread rapidly to poorer areas and smaller towns.

Country data based on case studies undertaken or co-authored by Thomas Reardon of Michigan State University (some of which discussed below) strongly suggest continuation and sometimes further acceleration of the transformation of agri-food chains in developing countries through supermarket procurement. An exception is Traill (2006) who quantitatively models the level of supermarket penetration for a cross-section of 42 countries at different stages of development. In one of the few comparative and quantitative studies to date he finds that openness to foreign investment, GDP per capita, urbanization, female labor participation rates and income distribution are all significant explanatory variables, explaining over 90% over variation in supermarket penetration. Using OLS regression analysis to project trends until 2015 (from a 2002 base), Traill arrives at much more modest retail shares for supermarkets, which would grow from 11 to 27% in China, from 1 to 3% in Pakistan and from 2 to 9% in India. These extrapolated figures however appear to be on the low side as they are possibly underestimating the fundamental nature of the changes taking place in agri-food chains.

Changing demand patterns are causing supermarkets to introduce technical, organizational and institutional innovations in what can be called the new supply chain, especially for perishable products such as fresh fruits and vegetables (FFV). Technical changes introduced in food chains include:

- Introduction of new crops that were unknown in Asia until recently such as courgette (zucchini), and asparagus;
- Use of high quality seeds and planting materials, such as hybrid vegetable seeds;
- Improved production practices: irrigation, greenhouses, plastic soil covering, hydroponics, drip irrigation, packages of inputs (fertilizers and pesticides) – as well as training on their proper use. Latrines and handwashing facilities in production fields to comply with food safety standards are other examples.

Organizational changes introduced include:

- Centralization of procurement – supermarkets are changing from a system in which each outlet did its own sourcing to a centralized system at retail chain level for the procurement of fresh products;
- Centralization requires another change: the establishment of distribution centers to supply the individual supermarkets;

- Change from traditional wholesale markets (spot markets or “wet” markets) to specialized, dedicated wholesalers. Supermarkets found that the old wholesale markets (often set up by governments) are inefficient and do not add any value to the product (packaging, grading etc.). Hence the shift to specialized wholesalers who often work exclusively for a single supermarket chain;
- To ensure high quality and reliability supermarkets are no longer buying from any farmer, but are shifting to a system of preferred suppliers with whom long-term relationships are established.

Key institutional changes required for the new supply chain to work smoothly are twofold. First, the introduction of contract farming, a change directly related to the preferred supplier system. The farmer (group) enters into a contract with the wholesaler or supermarket in which the supermarket specifies the varieties used, the production plan, plant protection measures allowed, etc. In return the supermarket often provides the inputs on credit and guarantees to buy the produce (provided it meets specified product quality standards). Second, (private) standards are another key feature of the new supply chain. Private standards such as EurepGAP and HACCP by themselves are reshaping agri-food systems (Busch 2002). They are usually stricter than public systems, they can significantly improve product safety and quality, and they create confidence between suppliers and buyers, but they often require sizeable investments by the farmers for which there is no compensation.

The new supply chain is characterized by much tighter vertical integration than the old supply chain. It increases efficiency by cutting out a number of actors that do not add value – thereby also reducing employment (Cadilhon 2006). In terms of broader impact, one can observe a significant shift of powers towards the end of the value chain i.e. towards the supermarket. This is a phenomenon found in Asia (Chowdhury et al. 2005) as well as in Europe (Gijsbers et al. 2006). Producer margins are under pressure, but the effects on producers can be mixed: Chowdhury et al. (2005) report for Indonesia that farmers in “modern” value chains receive a smaller percentage of gross value added in the chain, but in absolute terms they receive higher prices than producers in “traditional” chains. Whether this is enough to compensate for additional investment needed to participate in modern chains remains a question. The following section will look at agri-food chains and supermarkets in four countries.

11.7.1 Indonesia

The spread of supermarkets in Indonesia has gone faster and further than in the other three countries in this study – although there are big differences between the islands. In the 1970s and 1980s supermarket were limited to a few cities such Jakarta, Bandung, and Surabaya. In the 1990s smaller cities on Java saw supermarkets arrive and since 2000 cities in the outer islands are seeing the establishment of new outlets of national and international chains. This section draws on a detailed survey undertaken in 2006 by Natawidjaja et al. and on interviews held in 2003 with a number of commercial growers.

Although supermarkets had been spreading in Indonesia slowly since the 1980s, the big takeoff came in 1998 when, following the Asia financial crisis, and as part of a package of measures negotiated with the IMF, Indonesia revoked its ban on foreign investment in the retail sector. A rapid increase of FDI followed, led by Continent and Carrefour of France, and followed by a number of other groups: Wal-Mart (USA), Makro (Netherlands), and Giant (Hong Kong). Local department stores (Yogya) started their own supermarket chains and some convenience stores expanded and upgraded to become supermarkets. Between 1997 and 2003 turnover of supermarkets grew at 15% per year. The number of hypermarkets grew from 6-13 and the number of supermarkets from 1446 to 3590 between 1999 and 2003. The number of modern convenience stores is growing rapidly as well, especially in smaller towns. The share of modern retail grew from 21.6% in 2000 to 29.6% in 2004 according to AC Nielsen market research (reported in Natawidjaja 2006).

In 2006 the retail market was still experiencing a proliferation of chains – indicating that there was still room to expand. The concept of the hypermarket (introduced by Carrefour) was catching on and domestic chains such as Matahari were closing down department stores and supermarkets and converting them into hypermarkets. Interviews by Natawidjaja et al. suggest that the rapid growth will continue in the future. The main reasons mentioned are that modern retail is still in a learning process and becoming more efficient; that there appears to be much room to expand on the outer islands; and that continued strong FDI in the sector is expected. Key trends observed by Natawidjaja are:

- Diffusion beyond upper class to middle and lower class customers
- Diffusion beyond the greater Jakarta area to other cities on Java and then to other islands
- Diversification into new products: fresh fruits and vegetables (FFV) were of little importance in the 1990s, but increasingly so now.
- Continued reliance on imported FFV – surprisingly high at 60-80% of FFV sold in supermarket. The main reasons are high production and transaction costs of local produce; inefficiencies in production (spoilage, losses); high costs of inter-island shipping; and illegal charges by corrupt officials. This makes it hard to compete against China, Thailand and Vietnam which are lower cost producers than Indonesia.

Rapidly expanding supermarkets have restructured their supply chains in several ways. First, they have moved away from store-by-store procurement of fresh products from the local area to centralized procurement and the supply of outlets through distribution centers. All supermarket chains are expanding the number and size of their distribution centers. Second, they want to avoid traditional wholesale markets, which are unhygienic and inefficient. Instead, they are increasingly relying on dedicated wholesalers who specialize in a group of products. Cost savings of 20% are reported by cutting out the traditional wholesale market and moving to dedicated wholesalers. Third, imported FFV are channeled through importer wholesalers and sourced from hubs in Asia; this puts imported produce in direct competition with local produce. Fourth, local sourcing of FFV through specialized wholesalers involves establishing long-term relationships with the supermarkets. The wholesalers are sometimes producers of FFV themselves and sometimes they rely on contract farmers entirely. Fifth, supermarkets are keen to increase the share of local produce and reduce imports. Carrefour, for example, is developing programs to include Indonesian producers in its Filière Qualité Carrefour quality assurance scheme.

A number of modern producers who supply supermarkets were interviewed by Natawidjaja et al. from which a number of general findings emerged:

- There is a new elite of commercial farmers and wholesalers who supply the supermarkets – commercially managed, often by university graduates;
- In vegetables (where chains need to be especially short as the produce is highly perishable), modern producers interact directly with the supermarkets. In fruits specialized wholesalers play a key role;
- Modern producers have grown very rapidly from small beginnings to companies with a turnover of more than 1 million USD;
- The modern producers are unanimous in their opinion that the government agricultural extension service is of no use to them;
- Barriers to entry are quite high and consist of buildings, vehicles and a range of specialized equipment;
- Competition between modern suppliers is increasing and it is difficult to become a preferred supplier to a supermarket. Supermarkets use cheaper imports as an instrument to keep prices paid to local suppliers low;
- Modern producers, just as supermarkets, find that contracts with farmers-suppliers are hard to enforce.

At the farm level this has led to major changes in technology and in crop management systems as well as in logistics. The leading West Java vegetable producing area of Lembang (near Bandung,) has seen a decline in tomato production as it has moved up the value ladder to concentrate on new vegetables and flowers. Tomatoes are moving to areas that are just getting into vegetable production. New technologies include better irrigation systems, greenhouses and other facilities that require large investments.

Lack of capital is a key issue as is the problem of post-harvest handling, which is causing major losses. Other problems are insecure contracts, lack of transparency and price information, problems with farmer groups and non-functioning cooperatives, and delayed payments for produce by the supermarkets.

11.7.2 Pakistan

Supermarkets in Pakistan have expanded in recent years but are still very small in number and market share. Traill (2006) estimates that supermarket share of the retail business is 1%. According to ATKearny's 2005 Global Retail Development Index report, where Pakistan appeared for the first and only time in the top 30, the only identifiable chain, state-owned Utility Stores Corporation, had a share of 0.3 % of the market. Since then a few international chains have opened outlets (Makro in 2006) or are planning to do so (Metro). With a large population, rapid GDP growth (6% in recent years) and policies to attract FDI in place, Pakistan may become an attractive location, despite concerns over political stability.

Little information is available about supermarkets and their impact on agri-food chains in Pakistan. Almost no research has been carried out on this topic in comparison to the other countries in this study. What is clear however, is that in Pakistan supermarkets are catering mainly to urban consumers in the largest cities and that they concentrate on processed food products rather than on fresh products.

The most important impact of a private company on the agri-food chain in Pakistan is caused by Nestlé, the largest consumer goods company in Pakistan. Pakistan is the world's fourth largest milk producer and in March 2007 Nestlé opened its largest milk reception plant with a processing capacity of 2 million liters of milk per day, expanding to 3 million in a few years time (Nestlé 2007). Like in other countries such as Indonesia, Nestlé operates a highly sophisticated fresh milk collection operation, involving supplies from 140,000 farmers in the Punjab. Nestlé has for many years been working with producers to upgrade quality and safety of milk supplied to its plants. The systems operates through more than 3000 Village Milk Collection Centers, where farmers deliver milk twice per day and where it is checked by trained collection agents for quality and fat content. As part of its expansion in Pakistan and in partnership with UNDP, Nestlé has set up a CSR program entitled "Community Empowerment through Livestock Development & Credit", which aims at developing skills of women livestock holders.

11.7.3 Sri Lanka

The importance of supermarkets in Sri Lanka is growing, though not as fast as in other countries. Sri Lanka is a small market and international chains are not yet present in the country. The market is controlled by domestic chains which are spreading from Colombo to other cities. The market is dominated by a large chain, Cargill's Food City[70], which started in 1982 and has, at present, around 80 supermarket outlets. Other domestic chains have fewer than 10 outlets, including Keels, Sathosa and Kings. The number of single outlet supermarkets is increasing rapidly in smaller towns (Institute of Policy Studies 2006).

Despite growth, few Sri Lankans shop at supermarkets, and of those who do, only a third report buying fresh agricultural products there, most customers preferring traditional markets for FFV. Supermarket managers report that vegetables are not a very profitable product group, and that they are mainly stocked for availability purposes. Perera et al. (2006:76) conclude that "…the quantity of vegetables moving along these supermarket supply chains is comparatively insignificant as opposed to the quantity moving along the traditional channels."

While the overall impact of supermarkets on the agri-food chain in Sri Lanka is therefore limited, changes can be witnessed. While single outlet supermarkets source their FFV locally, the larger ones have centralized procurement.

Cargill's operates its own regional vegetable collecting centers located in the most important production areas. Farmers as well as smaller vegetable traders bring vegetables to these collecting centers after receiving purchase orders from the collection center. At the centers the vegetables are graded, sorted and packed for distribution. Prices offered are higher than in the traditional wholesale markets, and there is more transparency about prices. Traditional supply chains involve a larger number of intermediaries and they do not transfer price/quality signals back to the farmer. This has important effects on efficiency: "Post harvest losses are negligible along the vegetable supply chain of the supermarket (1 to 3 percent), whereas in

[70] Not affiliated with Cargill USA

the traditional vegetable supply chains the post harvest losses are as high as 35 to 40 percent" (Perera et al. 2006:74).

The relationship between actors in the supermarket supply chain is relatively open and arms-length. The collecting centers buy good quality produce from different farmers. Unlike in other countries, there is not yet a system of preferred suppliers, no prices agreed beforehand, no contracts between farmers and supermarket or distribution center, and no technical guidance to producers with regard to varieties and production practices.

Another case of establishing modern supply chains is MA's Tropical Food Processing Ltd. A family owned spice processing enterprise which has diversified into processed products such condiments, chutneys, and ready-to-eat meals. To ensure high quality and guaranteed supplies MA's has felt the need to work directly with (small) producers on improving its supply chain. It is especially interested in a steady supply of organically grown spices.

The main innovation introduced by MA's is that it has shifted its procurement system from a decentralized system to a centralized system. Centralized procurement is the responsibility of Regional Agribusiness and Perennial Crop Initiatives and Development (RAPID) companies. The centralization process increases the efficiency of procurement through a reduction of coordination. It assures a continuous supply of raw materials and eliminates nonessential intermediaries and middlemen. This has reduced risks and transaction costs, improved transparency and has led to improved margins, which are shared between the company and the suppliers. The RAPID center is also responsible for further improvement in pre and post-harvest production practices that improve quality and reliability. The most important innovations are:

- Backward integration: offering a set of support services to farmers (planting material, organic certification, credit etc.);
- Introduction of private standards and price premiums for those that meet these;
- Improving logistics through grading, processing, labeling, transport, etc.;
- MA's has established a preferred supplier status to supermarkets, and to companies like Nestlé and Unilever, airlines and hotels;
- As it grows, MA's is moving to specialized wholesalers to ensure quality;
- Quality assurance means that the company has introduced GMP, GAP and HACCP standards;
- Implementation of tracking and tracing systems are another innovation to improve quality and reliability;
- Corporate Social Responsibility: the company has initiatives on minimizing environmental impact of production, facilities for workers, support for education and for handicapped people.

Some 300 small producers are regular suppliers to MA's. The model has been in operation for more then 10 years and is constantly refined. It has brought some real innovation to this particular agri-food chain. Overall, however Sri Lanka as yet has not witnessed the transformation of production and supply system seen in other Asian countries and which could be expected of country with Sri Lanka's levels of per capita GDP. A major difference with countries where the supermarket revolution has already had a major impact lies in the fact that Sri Lanka's economy is highly regulated and FDI in its retail sector is still subject to a number of restrictions.

11.7.4 Vietnam

As in Indonesia, supermarket development in Vietnam has proceeded fast, although it started later and the number of supermarkets is still considerably lower, both because per capita incomes in Vietnam are still quite low, and because opening up the retail sector to FDI (required by WTO membership) is a recent policy. The spread of supermarkets in Vietnam is summarized in Table 11.2. (Muruyama and Trung 2007)[71].

Table 11.2 Number of supermarkets in Vietnam

Location/Year	1990	1995	2000	2004
Hanoi	0	2	20	73
Ho Chi Minh City	0	2	40	82
Entire country	0	10	107	210

Source: Based on Maruyama and Trung (2007)

During the time of the centrally planned economy very little private trade in food products took place. Following the 1985 reforms, the traditional market system was restored and private trade flourished once again, though the government continued to be a core actor. The first supermarket (Minimart), established in 1993) was a state-owned enterprise (SOE). A number of other local chains were established in the second half of the 1990s, some run by expatriate Vietnamese and not all of them successful. Since 2000 a number of foreign players have entered the market (in some cases as joint ventures with Vietnamese companies).

The main supermarket chains in Vietnam are:

- Metro, a German-owned supermarket chain, which opened in 2002, and established itself as wholesaler but which is also used by individual customers. It is the largest in turnover (220 mln USD in 2005) but not the largest in number of shops, as it concentrates on hypermarkets. It has two shops in Ho Chi Minh City, one in Hanoi, one in Can Tho, and plans for rapid expansion.
- Cora, renamed Big C, a French-Vietnamese venture, in Vietnam since 1999, with three hypermarkets in Ho Chi Minh City and one in Hanoi since January 2005, and with a turnover of 26 million USD.
- Coop-Mart, a national company, with government ties, involving public and private shareholders. It had 13 supermarkets in 2004 (12 in Ho Chi Minh City, 1 in Can Tho) and a turnover of 136 million USD.
- In addition there are some six smaller chains mostly in Hanoi and HCMC, from Japan, Taiwan, and recently, China.

[71] Moustier et al. based on a more restrictive definition arrive at somewhat lower estimates of supermarket penetration: 43 for Hanoi in 2004 and 71 for HCMC in 2005

Key trends that can be observed in relation to supermarket dissemination and development in Vietnam (Moustier et al. 2006, Muruyama and Trung 2007):

- Similar to other countries the main cities of Hanoi and HCMC are leading the way, with geographical diffusion to secondary cities about five years later.
- Like in Indonesia, at first supermarkets were carrying mostly imported goods, but that is rapidly changing and at present most have over 80% domestic products on their shelves.
- Supermarkets started with selling mainly processed food products and are then expanding to fresh fruit and vegetables.
- Modern retail establishments in Vietnam include a few hypermarkets, supermarkets and a large number of smaller convenience type of stores. Hypermarkets are located far outside the city centers and not easily accessible by those without cars.
- Prices for FFV in Vietnam supermarkets are not competitive with produce from the traditional wet markets, which retain a big market share for FFV
- At present the pattern is for most Vietnamese to split their purchases and to visit supermarkets for processed goods and buy FFV at traditional markets or from street vendors.

The rise of supermarkets in Vietnam has not yet impacted the governance of the food chain in the same way as it has done in Indonesia (more specifically Java). Supermarkets have not yet spread as widely as in Indonesia, and for most urban Vietnamese traditional markets remain the most important point of purchase for FFV. As a result, supermarkets have been less active in getting involved in organizing their own supply chains for FFV. Metro, the most important modern retailer for FFV operates a mixed model with close ties with some of their best suppliers for top quality produce, but also relying on a large number of small traders and suppliers with whom it has a much more arms-length relationship for lower priced produce. Still, in a case study comparing traditional and modern supply chains for tomato for HCMC, Cadilhon et al. (2006) find that the traditional wholesale channel handles 98% of tomatoes marketed. Thus, although growing rapidly, supermarket impact on agri-food chains in Vietnam is still limited compared to some other Asian countries.

Instead, a major actor in modernizing the agri-food chain is the Vietnam Government, which is strongly supporting the establishment of modern distribution centers, while closing down or modernizing traditional wholesale markets at the same time. The policy is mainly aimed at improving hygiene and food safety – prompted by a number of food scandals. As a result, modern distribution networks have grown at 15-20% per year since 2000, much faster than the growth in turnover of the modern retail sector or than GDP growth. The Government aims to set up 20 large distribution companies in order to handle 40% of fresh products by 2010.

Modern retail plays an important role in upgrading the quality of produce. While in traditional markets all grades are traded (though lower grades at a steep discount), modern supply chains simply reject substandard produce. Traditional supply chains offer no incentives for farmers to improve the quality of supply as required by the modern system. Supermarkets in Vietnam face a shortage of high quality produce because there is not yet an elite of modern horticultural producers, comparable to those in Indonesia, who established themselves as preferred suppliers to supermarkets and the hotel industry.

For Vietnam Moustier et al. (2006:1) observe that: "Poor farmers have no direct access to supermarkets because of the requirements in terms of safety (for vegetables), quantities and conditions of delivery (for all products). Yet, poor farmers can be indirect suppliers of supermarkets through the belonging to (or contracting with) farmers' associations supplying supermarkets."

Most vegetables supplied to Hanoi supermarkets are produced by "safe vegetable cooperatives", located at the outskirts of the city and which are emerging as new actors in the agricultural supply chain. These safe vegetable cooperatives were first established by the Ministry of Science Technology and Environment (MOSTE) in 1996 in response to a number of scandals over food safety (van Wijk et al. 2005). These safe vegetable cooperatives are usually new-style farmers cooperatives or transformed cooperatives that were formed on a voluntary basis after the old state cooperatives were abolished. The safe vegetable initiative requires the use of IPM measures to restrict as much as possible the use of pesticides; the use of ground water instead of river water for irrigation and other measures aimed to produce safe vegetables. Since 2003 the program has been replaced by a new certification scheme under the Plant Protection Department. Under the program testing of vegetables for chemical residues or other contaminants is limited, but according to van Wijk et al. (2005) social control within the cooperatives is strong and ensures that farmers comply with the rules.

11.7.5 Conclusions on supermarkets

1. The impact of supermarkets and agri-food companies on production and marketing in the agri-food chain can be very substantial. They introduce a number of wide-ranging technical, organizational and institutional innovations.

2. The effects of supermarkets on the agri-food chain to date differ widely between countries. In Indonesia, mainly on Java, effects have been most profound and have led to the emergence of a new class of elite horticultural producers. While there is concern about the exclusion of small and poor producers, modern horticultural practices are spreading to new locations, suggesting that barriers to entry may be high, but not insurmountable. Developments in Vietnam are some years behind Indonesia and consumers continue to rely more heavily on traditional markets for fresh food products. In Vietnam the Government is a key actor, not only because of its safe vegetables initiative, but also through its support for farmer groups and new style cooperatives. Sri Lanka and Pakistan are not yet at the stage where consumers rely heavily on supermarkets, and their impact on the agri-food chain has remained much more limited.

3. A key factor in Indonesia's rapid expansion of supermarket presence has been the removal of restrictions on FDI in the retail sector in 1998. In the other three countries different restrictions on FDI investment in retail are still in place. Expectations are that domestic and foreign investment in the supermarket sector will grow very fast, especially in Vietnam.

4. The liberalization of foreign investment in the retail sector can be seen as an important driver of innovation in the agri-food chain and may be comparable to the effects of trade liberalization.

11.8 NGOs and agricultural innovation

NGOs are very diverse group of organizations. They can be national or international, some are very large organizations, others are tiny rural groups. They usually work directly with local people, but they can also be involved in national level policy debate. Some NGOs are consultancy firms by another name.

In agricultural research, extension and innovation NGOs can play a wide variety of roles. They may provide services to farmers and they may be involved in the global policy debates on biodiversity, genetic modification and the effects of the DOHA round.

In their relationship with governments NGOs have been described as "reluctant partners" (Farrington and Bebbington 1994), indicating that often there is a complex and uneasy relationship between Governments and NGOs. There is often a lack of trust between grassroots NGOs and authoritarian governments in developing countries. NGOs find governments inefficient, corrupt and unresponsive to the needs of local people. Governments find NGO activism hard to deal with and question their legitimacy.

NGOs also have an uneasy relationship with technology. Farrington and Bebbington (1994) argue that there are two main tendencies in NGO approaches to technology which can be described as production-oriented or agroecological. Production-oriented approaches (essentially part of the green revolution paradigm, discussed in Chapter 9) come in two flavors: first, an *orthodox* model, which is largely supportive of the use of new varieties and of agro-chemical inputs and packages of technology to be transferred to different production systems; and second, a *grassroots-sensitive* model drawing only on those green revolution technologies, practices and institutions that are appropriate in local conditions and respond to producer needs. Similarly, the agroecological model (essentially the sustainability paradigm) comes in two shapes: pragmatic or ideological. Pragmatic approaches use low input technologies to respond to local needs and conditions. The ideological approaches often reject technology and modern inputs as a matter of principle. The ideological approach can be seen in the promotion of organic agriculture and in approaches that promote the use indigenous knowledge systems and cultural traditions in agricultural production on the basis of a belief in their inherent validity or superiority.

NGOs bring to the innovation arena specific strengths and weaknesses. Their main strengths are that:

- NGOs are often small, flexible and non-hierarchical;
- They are often represented in rural areas and in remote regions;
- NGOs have developed methods for assessing the needs of the poor (participatory appraisals etc.);
- NGOs are often instrumental in the formation of farmer groups;

- NGOs are often instrumental in bringing local knowledge to the innovation agenda;
- NGOs have developed informal dissemination methods (e.g. farmer to farmer extension);
- NGOs have sometimes developed new technologies or management practices (e.g. erosion control, integrated pest management, water catchments, local processing).

Weaknesses are that:
- NGO impact is often local as a result of their small size; scaling up is a key issue;
- NGOs have limited capacity for technology development;
- Accountability and legitimacy can be an issue: to whom are NGOs answerable?
- Competition between NGOs is sometimes unproductive.

NGOs play two main roles in relation to agricultural innovation. First, many play a role in the dissemination and transfer of technology – usually as part of a broader program of capacity building, skills development, rural development and social action. In fact, transfer of technology is not a popular concept with many NGOs: it is seen as part of the linear model of innovation thinking, where technology is developed by researchers, and transferred by extension agents or NGOs to farmers. NGOs on the other hand tend to stress the importance of farmer and local knowledge, and see innovation as a participatory process in which farmers are not passive recipients of packages of technology. NGOs aim to support the farmer's own innovative behavior and focus on learning, instead of technology transfer. Their solutions are often of a local nature and rely on intensive support from the NGO. This means that they are sometimes difficult to scale up to larger numbers of farmers or to other regions.

Second, NGOs often play a role as intermediary organizations, acting as facilitators in the innovation process performing a number of tasks. They may:
- Undertake needs assessments (diagnostic surveys);
- Play an advocacy role on behalf of the rural population;
- Be instrumental in the formation of farmer groups;
- Provide or administer (micro)finance;
- Serve as channels through which funding is provided to local initiatives;
- Be able to relate both to Governments and to private sector companies.

In Indonesia the number of NGOs has mushroomed after the end of the authoritarian Suharto regime. Civil society has blossomed in the *reformasi* era and there are now tens-of-thousands civil society organizations (Antlöv et al. 2005). They now have considerable influence in policy debates, but many NGOs are still relatively young and inexperienced, and governance and accountability issues need to be addressed. Government perceptions of NGOs have changed and it starts to see the need to define a division of tasks between government, private sector and civil society. The government still finds it difficult to establish effective partnerships with NGOs. Companies, which used to be hostile to NGOs are changing positions; gradually they see NGOs as useful partners in reaching out to local communities and to participate in CSR programs. NGOs have not played a major role in agricultural technology development and innovation. Most, according to Antlöv et al. are in fact urban-based and rather elitist. Exceptions are organizations such Bina Swadaya which have a long tradition in agricultural development.

In Pakistan the NGO sector is also growing quite rapidly despite the country having had a military government from 1999-2008. In line with international trends the government is increasingly supportive of the NGO role in development. The biggest influence here has been the Aga Khan Rural Support Program, a non-profit initiative later emulated by the government.

Sri Lanka has a long tradition of democratic government and of NGO involvement in development. A leading Buddhist-based NGO such as Sarvodaya has worked on rural poverty alleviation since 1958 and has programs in more than 11,000 villages. Many NGOs (supported by their international counterparts and donors) are involved in providing support to the victims of the civil war and the tsunami. In general, relationships between NGOs and the government are good, but a source of tension is formed by NGO involvement in the conflict in the North and East of the country. In Sri Lanka NGOs have also been involved in the implementation of World Bank funded Integrated Rural Development Programs (IRDPs).

In Vietnam, in the days of the centrally planned economy, the government was instrumental in setting up mass-based organization at local level. The Communist Party did not allow an independent civil society to develop. Since 1990, and particularly since 2000, more freedom has been given to voluntary groups to establish themselves as NGOs although registration and government approval are still required. According to Sabharwal and Huong (2005) the situation can be characterized by low, but growing tolerance of civil society activity.

A few conclusions can be drawn about the position and roles of NGOs. First, in all four countries the rise of civil society can be witnessed and the number of NGOs has grown rapidly. Second, NGOs have played quite a limited role in the development of new technology. Third, they have played an important role in the dissemination of new technologies and their adaptation to specific locations. Fourth, NGOs have played a key role as intermediaries and facilitators in agricultural innovation processes. Finally, NGOs have been instrumental in reorienting the public agricultural research agenda to focus on needs of poor rural families rather than production increases.

11.9 Overall conclusions

General conclusions in relation to private actors are presented below and the most important challenges are summarized in table 11.3.

1. Private sector agricultural research remains very limited in the countries studied. Multinational companies tend to centralize their research at their home base or at a regional research hub in Asia.

2. Instead, the multinational companies rely on existing technology embedded in seed and agrochemicals. They provide extension services linked to their product range to introduce

new technologies to farmers. If they require local technical support, private companies prefer to hire university staff as consultants, rather than working with government research institutes.

3. Asia is witnessing an impressive growth of supermarkets, especially in Indonesia and Vietnam, with much slower growth in Sri Lanka and Pakistan. The share of fresh products in supermarkets is particularly high in Indonesia.

Table 11.3 Summary: main challenges for private innovation actors

Challenges for private actors	Indonesia	Pakistan	Sri Lanka	Vietnam
R&D: develop technologies for needs of small producers	H	H	H	H
R&D: Create synergies with public R&D	H	H	H	M
Supermarkets: improve access to supply chains by small farmers	H	H	H	M
NGOs: establish credible role as innovation actors	M	H	M	H

4. Supermarkets are emerging as important innovation actors in the agri-food chains. Their impact is largest in Indonesia, but mostly limited to Java and a few other locations. Vietnam is following and rapid change is expected. Supermarkets in Sri Lanka and Pakistan are much less important as actors and consequently have a much more limited influence on innovation in the agri-food chain.

5. There are few linkages between the modern supply chains controlled by supermarkets and the government research and extension system.

6. Supermarkets affect the agri-food chain especially through centralized procurement and the introduction of quality standards. Barriers to entry are quite high, especially for small, poor farmers. Producers in the new supply chain receive a smaller share of value added, but usually have higher absolute returns.

7. NGOs play a limited role in technology development, but concentrate on different types of technology transfer and skills development. Their most important role is acting as intermediary organizations.

Part III Synthesis and Conclusions

12. Synthesis: agricultural innovation networks

12.1 Introduction

Part III of the study provides a further analysis of the information presented earlier in two ways. This chapter focuses on linkages and agricultural innovation networks, providing a synthesis of findings on the roles of different actors, drivers and paradigms. Chapter 13 presents conclusions and recommendations.

Innovation entails a wide variety of activities – all related to learning, knowledge and technology. Innovation may require the acquisition, generation, adaptation, transfer, dissemination and commercialization of new knowledge and technology. Organizations increasingly discover that they can not cover the entire knowledge chain alone and are moving towards open innovation models (Chesbrough 2003) in which not all new technologies or solutions are developed in-house. Innovation involves make-or-buy decisions, where parts of the solutions are found in other companies or organizations (Foster 2000). In short, innovation takes place in partnerships and networks. Powell and Grodal (2005) discuss networks in relation to technological uncertainty and observe that research has shown that "…networks provide access to more diverse sources of information and capabilities than are available to firms lacking such ties, and, in turn, these linkages increase the level of innovation inside firms."

In agriculture, as opposed to manufacturing industries, innovation has always been much more of a distributed process. This is related to the fact that agricultural producers are geographically spread out in rural areas and have different requirements, depending on the specific resource endowments of their production systems. Another reason is the traditional importance of governments in agricultural innovation, resulting from public concerns for food security and food safety.

The innovative performance of organizations is determined by how effectively they engage with other actors in the agricultural innovation system. This chapter aims to provide a synthesis of analyses in the previous chapters on the roles of different public and private actors by answering the following questions:

1. What types of agricultural innovation networks exist (12.2.1)? How do networks relate to the four innovation paradigms (section 12.2.2-12.2.5)? What innovations happen at the interface of the four paradigms (12.2.6)?

2. What types of innovation linkages and networks have been established by agricultural research organizations with other actors in the agricultural innovation system in four Asian countries (12.3)?

3. How can the agricultural innovation performance of the four countries (presented in Chapter 8) be related to the nature and types of innovation linkages and networks, and to the adoption of different innovation paradigms (12.4)?

12.2 Networks and paradigms

12.2.1 Network types

Different paradigms lead to different configurations of linkages and networks. Chapter 5 presented the central concepts and elements in the analysis of innovation and networks. These include the roles of network actors, the relationships between actors (internal network dynamics, external dynamics and dynamics over time), the scope, content and activities in networks, and network resources.

There is a close fit between the network types presented by Powell and Grodal (2005) and the four paradigms introduced in Chapter 6. Figure 12.2 shows the correspondence between network types and paradigms. The green revolution is highly institutionalized and corresponds closely to the organizational network type. The sustainability paradigm is much more distributed as a community of practice across organizational boundaries. Biotechnology innovation usually requires large investments and complementary assets in formalized strategic alliances. Agri-food chains, dominated by supermarkets follow the supply chain model.

Figure 12.1 Paradigms and networks

	Informal	Contractual
Closed networks	**Green revolution** • Public Research • Shared view of technology • Dense structure: CGIAR network • Established network, seeking new tasks • Mission creep	**Supermarkets** • Producers, processors, retailers • Common task: organize food chain • Technical standards, contract farming • Horizontal and vertical specialization • Division of labor • Controlled by retailer
Open networks	**Sustainability** • Public research and other practitioners • Bottom up, against Green Revolution • Horizontal across institutes • A “movement” – farming systems movement	**Biotechnology** • Life science companies, venture capital, producers • IPR: patents, MTAs • Strategic alliances around IPR • Combination of assets, skills

12.2.2 Organizational networks and the green revolution

The green revolution paradigm has become dominant since the late 1960s and has evolved into a highly structured network. At present, the CGIAR network with its membership consisting of international donors and national governments in developing countries, its research done by its 15 international research centers in partnership with national agricultural research centers, and its Secretariat under a Vice President of the World Bank, forms a dense network of activities. Public agricultural research organizations in developing countries (whether or not they are members or donors of the CGIAR) are the main beneficiaries. They have been secondary actors in the past, but are increasingly involved in decision-making. In addition, outside actors influencing the CGIAR include NGOs who are critical of the CGIAR's work with private companies notably on biotechnology. NGOs have also successfully campaigned for transferring governance of the CGIAR Centers' gene banks to an intergovernmental organization, the FAO.

The density of events within the CGIAR network is further demonstrated by the fact that there are pressures to move towards a single research organization and to bring the 15 research centers (each with their own set-up of directors and Board of Trustees) under a single governance structure. So far the individual CGIAR research centers have successfully resisted these moves towards consolidation, though they are moving towards closer collaboration as a result of system-wide reviews and donor funding available for a number of multi-center global "challenge programs", for example on climate change. Donors use the leverage that their funding provides to steer the CGIAR towards the types of performance they see as producing desirable outcomes, for example by pushing for poverty alleviation through agricultural research.

The CGIAR is a relatively closed network. This is demonstrated in a study by Spielman et al. (2007) on public-private partnerships (PPPs) entered into by the CGIAR research centers. They found a total of 75 PPPs for 15 centers with just three centers accounting for over 50% of the number of partnerships. The authors (associated with the CGIAR) conclude that: "[t]his study suggests that while PPPs are serving a wide variety of research objectives, the CGIAR's partnerships with the private sector are still at a very nascent stage. Few partnerships are explicitly designed to facilitate joint innovation, an important justification for the use of PPPs. Still fewer provide for effective management of the risks inherent in PPPs or provide effective analysis of their poverty-targeting strategies" (Spielman et al. 2007:5). It appears that, as a network, the CGIAR is characterized by overembeddedness, defined by Uzzi (1997) as a situation where current strong ties inside a network limit the opportunities and incentives to look outside the network.

As discussed in earlier chapters the green revolution in Asia has had a very substantial impact, not only through the varieties, technologies and management practices introduced, but also through providing training to several generations of agricultural researchers. All four countries in this study have been major beneficiaries of the new rice varieties, and Pakistan from wheat research as well. Indonesia and Sri Lanka are each hosting one of the 15 international CGIAR centers. At national level the public agricultural research organizations are the core of the green revolution network. Relationships in the public research system are hierarchical in nature and characterized by strong vertical relationships and the absence of horizontal linkages across institutes in the broader innovation network. National research organizations form a well established, relatively closed network, but they are becoming more open at the margins as research funding is opened up to competition and sustainability concerns are becoming integrated in the green revolution model. Competition is emerging from the private sector, which is commercializing broadly adapted hybrid maize and vegetable varieties. At present public research networks have low levels of IP protection – but as a result of increased competition the protection of IP is becoming more important (e.g. through plant breeders' rights).

12.2.3 Communities of practice and sustainable innovation approaches

The sustainability paradigm started as a counter movement against the high input-high output types of production technologies typical of the green revolution. It emphasizes the need to manage natural resources responsibly, to focus on the whole farming system, rather than on a single technology package, and to address the poverty problem in a much more direct manner. Compared to the green revolution it has remained a much more diverse paradigm and much more distributed in its organizational set-up, without a central core actor, or group of actors, to provide governance. It is indeed a community of practice, or rather a number of communities of practice, some addressing problems of land and water management, others involved in farming systems research, and yet others advancing the state-of-the-art in integrated pest management. As a result of the general concern about sustainability the CGIAR institutes have since the 1980s gradually incorporated the ideas of the sustainability paradigm. At present communities of practice under the sustainability paradigm may include researchers working at the CGIAR institutes and at other research and development organizations. At the same time there are researchers at the more radical NGOs who would not consider working with the CGIAR institutes.

The sustainability paradigm includes a wide variety of approaches and schools: farming systems research and development, natural resources management, integrated pest management, farmer field schools, indigenous knowledge models, sloping agricultural land technologies, ethno-veterinary practices, low external input agriculture, etc. This implies that there are many networks, which tend to be fragmented in nature and relatively small. Funding levels are low compared to what has been invested in the green revolution paradigm, but since no new varieties, machinery, or inputs are usually developed, and as research is done mostly in farmers fields, no major capital investments are required. Donors to the CGIAR Centers have supported sustainability networks financially as they saw it as a way to get environmental concerns on the agenda of the CGIAR institutes and to promote partnerships between CGIAR Centers and organizations working on environmental issues, rural development and poverty alleviation.

Sustainability networks often depend on international funding[72]. Linkages have tended to be stronger between national and international actors in the networks than between actors within

[72] The International Development Reserch Center (IDRC) of Canada has been a major supporter and promoter of the farming systems approach to agricultural research, involving both the CGIAR and other research and development organization. FAO has been a major supporter of Integrated Pest Management work.

the same country. The reason that, at the national level, sustainability networks are not well integrated with public national agricultural research is the absence of effective linkages between public agricultural research organizations and other organizations in the innovation system.

Sustainability networks are mostly egalitarian, and open to new participants. There is no hierarchical control over participation, which is usually of a voluntary nature. The types of knowledge, technology and management practices developed are mainly of a tacit nature. Knowledge and technology is common pool or public good in nature and protection of IP would go against the open source nature of the network.

12.2.4 Strategic alliances and biotechnology innovation

Biotechnology networks often start as community of practice type research networks. When research is ready for commercialization (when they shift from doing research to innovation) they may evolve from communities of practice to strategic networks. To scale up, or commercialize academic biotechnology research usually requires large investments beyond the possibilities or mandate of a university or public research institute. Linkages in a strategic alliance are contract-based with a prominent role for intellectual property. Key actors are the major life sciences companies, high-tech startups specializing in a core technology and venture capital firms. The regulatory framework with regard to biosafety and food safety plays a key role in investment decisions.

In the USA and Europe high-tech start-up companies, are often spun out of university research groups or public research organizations with support of venture capital. In due course successful high-tech start ups are acquired by large diversified companies who aim to benefit from a specific product or technology. An alternative arrangement, of which there are examples from the USA, involves biotech companies investing in university departments. Examples are the US$ 25 million agreement between the University of California (Berkeley) and life sciences company Novartis in 1998 and the BP oil company agreement with UC Berkeley and the University of Illinois to develop advanced biofuels in 2007, worth US$ 500 million. These arrangements (like many arrangements in biotechnology) have turned out to be controversial (Altieri and Holt-Gimenez 2007).

For developing countries in Asia these types of partnerships are slow to emerge with the exception of India and China, with their vast pools of researchers and huge potential markets (Niosi and Reid 2007). Both countries are rapidly becoming more attractive for life science companies as they have since 2000 tightened their formerly lax, and non-standard IPR legislation in compliance with WTO membership.

A number of (agricultural) biotechnology initiatives in Asia are essentially based on public donor funding (sometimes with private and philanthropic contributions). The USA has for many years supported a number of research capacity building projects such as the Agricultural Biotechnology Support Project (ABSP), and projects to upgrade developing country capacity to build adequate biosafety systems, such as the Program for Biosafety Systems (PBS). Another program run by the International Service for the Acquisition of Agri-biotech Applications (ISAAA) has facilitated the transfer of proprietary technology from life sciences companies, such as Monsanto in the North to national agricultural research organizations in developing countries. [73]

Another initiative, supported by the Asian Development Bank, is the Asia Maize Biotechnology Network (AMBIONET) from 1999-2004. Like many of the donor supported biotechnology networks this was a public research and training network, with limited participation of the private sector. AMBIONET is a good example of a community of practice research network: it was coordinated by CIMMYT, the CGIAR Center working on maize and the donor used the existing CGIAR network and its relationships to establish a new one. It involved other actors, and when donor funding stopped the network's activities came to an end.

12.2.5 Supply chains and the supermarket revolution

Supply chain networks or agri-food chains are usually dominated by one or a few core actors, either processors or retailers (supermarkets). They integrate dissimilar actors around a specific set of tasks i.e. converting raw materials into a final consumable product in a supermarket. Its objective is to achieve vertical integration in the production column. The core actor in an agri-food chain is often a retailer with different tiers of suppliers and with downstream linkages with consumers.

Network coordination and integration is achieved by direct control mechanisms such as contracts, logistics (just-in-time delivery), as well as the use of private standards to control product and process quality. Supply chains may be national, regional or global. Established supply chains may evolve into organizational networks, when existing network dynamics (information, trust) form the basis for undertaking new types of activities. Some critical linkages in the supply chain may be internalized when a company in the chain decides to acquire (part of) another company in the chain to ensure long-term supplies of critical inputs. On the other hand, if a supply chain is no longer performing well, it may open up to include new partnerships through strategic networking arrangements.

Agri-food chains have been globalized for a long time in the case of commodities such as spices, beverages, grains, meat and non-perishable dairy products. Increasingly, global trade is also having an impact on fresh fruits and vegetables, flowers, fish and other perishable, high-value products. As a result of falling transport cost, improvements in post-harvest and storage technology, improved logistics, information management, and changing dietary preferences, the world has seen a growing integration of developing country suppliers in geographically dispersed global or regional networks (Ruben et al. 2006).

In addition to globalization the most important change that has taken place in food chains is the replacement of spot markets with networks of specialized preferred suppliers for sourcing raw materials and intermediate products (Reardon et al. 2004). This has shifted decision-

[73] These initiatives have all received support from the US Agency for International Development (USAID). There appears to be a direct relationship between the US position on biotechnology (and more specifically its positive attitude towards genetic modification) and the support of capacity building initiatives. European donors have been more reluctant to support this type of work and have concentrated on biosafety an environmental impact issues.

making power towards the end of the food chain, and most chains have become buyer-driven (Gereffi 2001). The shift to preferred suppliers has also had a major impact on the organization of the chain and has affected primary producers in a number of important ways, especially in the upgrading of production processes and products through the introduction of quality standards. Dealing with quality and safety issues has resulted in companies controlling their sourcing much more effectively in an effort to close loopholes. As a result agri-food chains have become more closed networks with high barriers to entry for producers.

The main results of the analysis of paradigms and networks are summarized in Table 12.1.

12.2.6 The dynamics of innovation within and between paradigms

What are the longer-term perspectives for agricultural innovation in Asia? This section elaborates on the dynamics of innovation by looking first at network dynamics and trajectories within each of the four paradigms and then at more radical innovation options at the interface of different paradigms. A longer term perspective is required as the paradigms differ greatly in maturity. For example the impact of biotechnology is as yet limited because of regulatory issues and concerns about ethics and safety related to this radically new technology. But over the long run it is likely that many radical innovations will stem from this technology.

Paradigms provide a powerful selection environment within which technological trajectories are shaped. On the one hand paradigms are stable because they are based on a strong internal logic and a set of common assumptions. On the other hand, as Kuhn already emphasized, paradigms may constrain the development of new questions and answers, becoming blindfolds over time. Geels and Kemp (2007) distinguish three types of change in socio-technical systems. ***Reproduction*** can be seen as incremental change along an existing trajectory, ***transformation*** involves changing the direction of the trajectory, and ***transition*** requires a discontinuous shift to a new trajectory. Here, a distinction is made between innovation within a paradigm (reproduction) and innovation at the interface of two paradigms which may be either transformation or transition.

The green revolution reached its zenith in the 1970s when the new high yielding varieties of rice, maize and wheat became widely adopted throughout Asia's lowlands. By the mid 1980s there was already talk of a post green revolution situation as most farmers in lowland areas had adopted new seed, fertilizer and agrochemicals packages (Byerlee, 1987). The post green revolution situation was concerned with much more complex production situations (e.g. multiple cropping systems, upland environments). The post green revolution situation also had to address a number of problems that emerged as a result of intensive mono-cropping, including the buildup of pests and diseases, such as the brown planthopper in rice, and the emergence of iron and aluminium toxicity in rice paddy fields.

Table 12.1 Overview of network characteristics for the paradigms

	Green Revolution	**Sustainability**	**Biotechnology**	**Agri-food chain**
Network type	Organizational network	Community of practice	Strategic Alliance	Supply chain
Network actors	Developed country donors, World Bank, CGIAR Secretariat, 15 international research centers, national public agricultural research organizations	Individuals, private non-profit organizations, research organizations, international organization, donors	Life sciences companies, producers, consumers	Retail chains, traders, producers
• Number of actors	Large, global network, complex governance National level public research and extension networks	Global movement, distributed, complex National and local level groups	Small number of core actors, small number of producers in developing countries, due to regulatory issues	Relatively small number of core actors (supermarkets), larger numbers of distributors and very large numbers of producers
• Types of actors	Public sector dominated	Public, NGOs	Private, strong public regulation	Private retailers, processors and producers, weak public regulation
Network relationships				
• Internal dynamics	Coordination and hierarchy type of relationships	Egalitarian networks, communities of practice. Coordination type in research	Ownership and IP based exchange, direct control	Direct and structural control, based on ownership, contracts and standards.
• External dynamics	Relatively closed network, open at the margins	Open, informal and formal relations	Competing life science companies, government regulation	Closed network of buyers, producers and middlemen Competition between supermarkets and value chains.
• Dynamics over time	Mature network, incorporating new models	Increasing incorporation in public research and in private companies (People, Planet, Profit)	Networks of alliances, based on IP exchange, cross-ownership High-tech startups acquired by big companies	From spot markets to long-term contractual relations with preferred suppliers.

Table 12.1 Overview of network characteristics for the paradigms – continued

Network scope and complexity				
• Vertical integration	Limited, mainly research actors	Limited	High	High
• Horizontal differentiation	Increasing: incorporating elements from other paradigms	Broad, different schools, low barriers to entry	Focus on selected key technologies, practices	Depends on the length of the values chain for the product
Network resources				
• Resource creation, types	New varieties (tangible), management practices (intangible)	Mainly new knowledge on sustainable practices (tacit, intangible)	Codified knowledge, embodied technology (hybrid varieties, biomarkers, GM plants, etc.)	Logistics knowledge (tacit, codified), value added to products
• Resource use, assets	Donor driven, large investments	Distributed, dispersed funding	Mainly private, large investments	Distributed investment, outsourcing, technology to upgrade production processes
• Control over resources	Structural and direct control	Exchange, public domain, open source	Direct, licenses, contracts, IPR	Direct, contractual relationships. Public and private standards
• Resource exchange	transfer of technology, seeds varieties	Learning networks, common pool	Material transfer agreement	Raw materials to final product,

To deal with these problems, systems approaches emerged both as a reaction and as a complement to the green revolution. The cropping and farming systems approaches which spread rapidly in the 1980s are the first manifestations of the sustainability revolution. While both the green revolution and the sustainability revolution were public and not-for-profit, there were also important differences: the green revolution was technology-driven and pushed from the top down by governments eager to modernize agriculture (Parayil 2002); the sustainability revolution was very much bottom-up and focused on improving management practices rather than introducing new production technology. While the green revolution was based on relatively consistent set of ideas, the sustainability revolution included a wide variety of approaches and viewpoints. While the more moderate farming systems researchers started to work with researchers from national and international public agricultural research institutes, the more radical currents maintained their distance to the green revolution. Collaboration between the green and the sustainability paradigms were difficult at the beginning, but the two are becoming much closer for two reasons. The first is that sustainability has become more and more mainstream in both public and private sectors, caused by increasing environmental problems at the local (e.g. erosion) as well as the global level (e.g. climate change). The second factor is that in many Asian countries relationships between public research and NGOs, who are important players in the sustainability revolution, are improving. Civil society organizations are increasingly important in the public discourse, and there are growing demands for public research to become more transparent – the "see-through science" approach (Wilsdon and Willis 2004).

The biotechnology or gene revolution has been presented as a natural continuation of the green revolution. Parayil (2002) however, shows that the two paradigms are "entirely different socio-technological systems", based on fundamentally different principles: "Efforts to revive the green revolution under the rubric of a "Doubly Green Revolution" […] did not take off due to privatization of the research infrastructure and technology transfer regime after the end of the Cold War, and also due to the influence of neo-liberal doctrines curtailing international aid and capital and technology flow gravitating to new players on the international arena." (Parayil 2002: 972). Whereas the green revolution was an international public, non-profit modernization project at the time of the Cold War, the biotechnology paradigm was shaped in a very different selection environment: i.e. in the post Cold War liberalized global economy where private, for profit companies are the core actors and foreign investment and protection of intellectual property are the key instruments. Public research organizations are however becoming involved in the biotechnology paradigm, which is leading to questions about the public nature of knowledge. The strategic alliances that Novartis and BP have established with US universities, are examples. Public research organizations build up their own portfolio of biotechnology IP, not just to benefit from it through technology licensing, but also to use as a bargaining tool to obtain access to restricted knowledge of other public or private organizations. At the same time keeping an important body of biotech knowledge in the public domain has become an important challenge for public and non-profit research organizations.

Some innovation is taking place at the interface of agricultural biotechnology and the sustainability paradigm[74]. An example is the attempt to "tailor" biotechnologies to the needs of specific target groups such as poor farmers (Ruivenkamp 2005). This involves methods to produce disease free planting materials and propagating elite planting material for crops such as banana and cassava and for tree crops. Technologies such as molecular assisted breeding are used to develop drought resistant varieties for crops such as maize and sorghum. Generally though, trust between biotechnology researchers and proponents of sustainable development is low and collaboration is limited.

The supermarket revolution is driven by private, for profit interests. No radical new hard technology is involved, but new combinations of existing technologies and strict standards and logistics provide a powerful innovation trajectory. At the interface between the agri-food chain paradigm and the green revolution, little innovation is taking place as the staple crops of the green revolution are of less importance to supermarkets than high value products such as fresh fruits and vegetables, dairy products, meat and fish. Public agricultural research

[74] In industrial biotechnology which aims at replacing chemical by biological processes the relationship between biotech and sustainability is much stronger than in agricultural biotechnology.

institutes (mainly universities) are sometimes involved as consultants for supermarkets in fine-tuning production technologies for specific regions and training farmers in new production packages.

There is (at least for the time being) little scope for innovation at the interface of the biotech and the supermarket paradigms. The major supermarket chains steer clear of biotechnology as consumers and governments (especially in Europe) have rejected genetically modified (GM) products. As a result, supermarkets in many countries go to great lengths to ensure that their commodity chains are GM free.

On the other hand there is considerable potential for innovation at the interface of the agri-food chain and sustainability paradigms. Supermarkets and the food companies that supply the bulk of their products are increasingly keen to promote sustainable development. Corporate social responsibility is important for the international companies such as Unilever, Nestlé, Makro, Carrefour, and national companies in Asia are following their lead. The possibilities for innovation at the interface between paradigms are graphically illustrated in Figure 12.4, where the width of the arrows indicates the possibilities for innovation.

12.3 Linkages and partnerships in Asian agricultural innovation

12.3.1 Actors, linkages and embeddedness in innovation networks

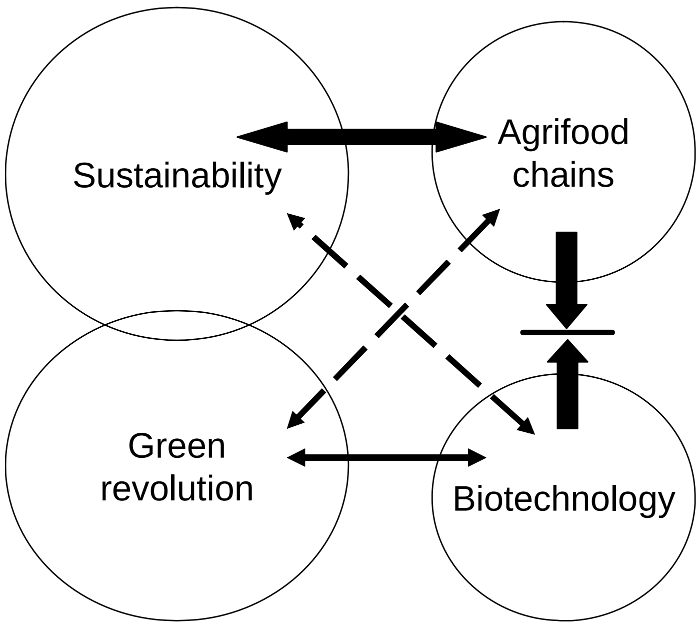
The idea of networks as a specific form of governance different from market and hierarchy (Powell 1990) has been widely accepted. Market forms of organization are the basic model of governance in the production and distribution of private goods and the production of public goods is the core business of public organizations. Following this analogy networks are best suited to produce the kind of common pool or club goods that are neither fully public, nor fully private[75]. Neither markets, nor governments work perfectly well, and their activities, or lack thereof, leads to inefficient allocation of goods and services in the economy. These situations are referred to as market failure and government failure. Similarly, the term "network failure" may be used to describe a situation where cooperative arrangements between organizations are not working in such a way as to produce the (innovation) outcomes expected.

Two common situations where network failure occurs relate to underembeddedness and overembeddedness of network actors and relations. The situation of overembeddedness was described above in relation to national public agricultural research systems in Asia, and to a smaller extent in relation to the international network of agricultural research organizations. Viewed from a national innovation system perspective in developing countries however, including in Asia, the opposite situation of underembeddedness is the rule: crucial linkages are missing to generate, adapt and transfer new technologies and management practices – as shown in section 12.2 above.

[75] As agriculture becomes more knowledge intensive, the importance of pure public goods diminishes and that of common pool goods increases.

Embeddedness may be analyzed at different levels: international, national, sectoral, and regional or local. Agricultural innovation systems are sectoral innovation systems that consist of three main components: sectoral knowledge and technology, actors and networks, and institutions (Malerba 2006). The networks found in agricultural innovation systems operate at international, national and regional or local levels.

Figure 12.2 Potential for innovation at the interface of paradigms



The international embeddedness of Asian agricultural innovation systems is increasing rapidly, but more so in Southeast Asia than in South Asia. Growing FDI has been a major contributor to the rise of an Asian food system and to the emergence of global agricultural value chains. International technology transfer from private agribusiness, biotech companies and from retailers is increasing rapidly. Recent years have seen the emergence of powerful agricultural research organizations in China and India, working on advanced biotechnology and plant breeding solutions such as the development of hybrid rice.

As Carlsson (2006) observed, innovation activities rapidly become more and more internationalized, but the institutions that support innovation processes remain largely national. This is a major problem in agricultural innovation where the national level supporting institutions in Asia are almost completely in the public sector hierarchy. Even within the public sector there are different hierarchies (such as research and extension) among which linkages are ineffective. Overembeddedness occurs within narrowly defined subsets of the national innovation system (i.e. within research systems) and limits the interactions with the outside world. At the level of the innovation system, however, public sector technology development is characterized by underembeddedness, with some organizations concentrating on research, others on extension and yet others on the provision of inputs – but without effective integration.

At regional and local levels processes of service delivery, technology transfer and adaptation, experimentation and learning that form the cutting edge of the agricultural innovation process are suffering most severely from the problems of ineffective linkages and underembeddedness – even though the problems differ between innovation paradigms. While in Indonesia and Vietnam supermarkets are increasingly important in restructuring the supply chain and in upgrading production, there are indications that for small producers it is difficult to meet the retailers' quality standards.

Market failure leads to calls for government action. Similarly, in situations of government failure the private sector may step in to provide the goods. Here the question is what can be done about this situation of network failure in agricultural innovation systems? Which organizations can play the role of network integrators, especially with respect to small producers who are often locked out of innovation networks? Overcoming network failures would appear to be a public task, as private companies will not normally invest in networks beyond their own value chains, and NGOs are not usually capable of achieving integration between a variety of actors. In addition, private company and NGO investment in agricultural R&D remains minimal in Asia. And at the same time, government hierarchies, with top-down decision making and characterized by compartmentalization have so far proven to be largely incapable of encouraging linkages and horizontal, non-hierarchical types of networking.

12.3.2. Assessing actor linkages in innovation networks

Chapter 10 indicated that the key weakness of public agricultural research organizations is their limited capacity to engage effectively in inter-organizational partnerships and networks. The reason for focusing on public agricultural research actors is that they account for over 90% of the agricultural research effort in Asia, and that they are (or should be) leading actors in innovation networks. That his is not often the case is demonstrated in a collection of agricultural innovation case studies by the World Bank (2007a).

This section analyzes the linkages between actors in a number of Asian agricultural innovation systems. Linkages are defined as the coordinated channels for exchange or flows of technology, information and resources between organizations in an agricultural innovation system (Peterson et al. 2003). These exchanges or flows can be achieved in different ways by establishing linkage mechanisms that address specific purposes or functions. Linkage mechanisms are procedures that enhance technology generation and exchange, and which enable the flow of information and resources. Examples of mechanisms include joint planning meetings carried out by key partners, memoranda of understanding, contracts between organizations, joint priority setting with partner participation, staff exchanges between organizations, etc.

In each of the four countries an assessment was made of the effectiveness of linkages and partnerships between public agricultural research organization and other relevant actors in the agricultural innovation system. This involved a number of workshops in the four countries with the research organizations presented in chapter 10. These workshops were aimed at identifying linkage constraints and options for improving linkages with other agricultural innovation actors. In Indonesia this analysis was conducted at the level of IAARD, with a more in-depth review of linkages in horticultural and animal research. In Pakistan the analysis was undertaken for the National Agricultural Research Center (NARC). In Sri Lanka and in Vietnam the assessment was done at institute level, for the Coconut Research Institute and for the National Institute of Animal Husbandry respectively. The linkage assessment and planning work followed a consistent approach in each of the countries, using a matrix-type of instrument to systematically present linkages between innovation actors.

The assessment of linkages in this approach involves the following steps:

- Identification of key linkage partner organizations (Who?);
- Identification of the main functions (or tasks) for each type of partner organizations (Why?);
- Identification of the main mechanisms or instruments to be used (How?);
- Planning for improving linkages (identify gaps, design new mechanisms, provide budgets, sign MoUs).

The most important potential linkage partners for agricultural research organizations include: farmers, farmer organizations and farmer cooperatives; government extension services; other research organizations in the public sector; international and regional research organizations; NGOs; private sector actors/users in research and technology transfer (agribusiness, processing companies, research and input suppliers); donor and development agencies (external investors and stakeholders); and government policy and decision making bodies.

For each of the different partner types there are specific reasons to establish and maintain effective linkages. For example, linkages between research and extension organizations are needed for making research outputs and results available on a timely basis, for training of extension staff in new research methods, for preparation of information materials and methods, for conducting field days, demonstrations and on-farm research activities. The functions of linkages with international research organizations include providing access to global technology, obtaining training, improving regional cooperation on shared research problems, and avoiding duplication of research efforts.

12.3.3 Indonesia

Decision making in the Indonesian public sector has traditionally been very hierarchical. Since the beginning of the Reformasi era (following the fall of Suharto), decentralization has become a key issue in Indonesian society. But centralization of decision-making has very much been a part of the organizational culture of the Indonesian civil service and despite the radical devolution of political power to the regions since 2000, actual decision making processes remain very hierarchical. Thus, the need for public administration reform in Indonesia remains compelling (Rohdewohld 2004).

Partnerships between the Indonesian Agency for Agricultural Research and Development (IAARD), the research arm of the Ministry of Agriculture, and other actors in the agricultural innovation system are new and have been limited in number. Involvement of stakeholders in IAARD decision-making is non-existent. An opinion frequently heard within IAARD is that “they cannot operate our system” – though on occasion stakeholders are invited by IAARD for consultations. IAARD had limited experience in setting up and managing new partnership and networking arrangements, but has made progress in developing different types of contracts to manage partnerships with a variety of clients – mainly due to the government’s commercialization policy, which started after the year 2000. But commercialization contracts are new arrangements which have been functional only in a few research institutes. And besides formal networks it is also important to develop informal types of networking – with which there is even less experience at IAARD.

Chapter 10 analyzed the **internal linkages** within the large IAARD system and concluded that these are to a large extent determined by the creation of the Assessment Institutes for Agricultural Technology (AIAT) in 1994. AIATs have a specific responsibility to stimulate farmer participation in research needs assessment and priority setting. The separation of the AIATs and the national level commodity research institutes has (at least initially) complicated the establishment of internal linkages.

Linkages with agricultural **extension** organizations were well established in the past, but were complex and not very effective. Now, the responsibility for extension is devolved to the provinces and has diminished in importance. The establishment of AIATs, which incorporate part of the extension organization, was an effort to improve the flow of information and technology between research and extension. But the integration of extension and research under the AIAT umbrella has not been an easy task.

The workshops found that ineffective linkages between agricultural research and extension organizations have caused a lack of attention to farmers’ problems in the research agenda, and have hampered the dissemination of research results. The 2006 Extension Law (Law No. 16/2006) stresses the need to involve a variety of public and private providers in extension in order to improve productivity and incomes (World Bank, 2007b). Meanwhile, the private sector (Pioneer, Monsanto, Cargill) has established a major seed production, extension and marketing effort of its own on hybrid maize, which is rapidly being adopted, especially in parts of East Java.

IAARD has had its most intensive collaboration with **universities**. This is largely the result of donor-funded activity. An example is the World Bank funded Agricultural Research Management Projects (ARMP I and II), which established a competitive fund for research. Under the ARMP II project (1997-2003) a total of 210 research projects have been implemented at a cost of just over 1 million USD. (This amount represented 70% of funds disbursed under the project; another 26% was used for research with the private sector, and 4% for work with international centers). The relationship is basically limited to funding of research activities undertaken by universities. It is government policy to turn universities into autonomous institutes, which increasingly have to seek their own operational funding. The three interuniversity biotech centers, at IPB Bogor (agriculture), ITB Bandung (industrial), and UGM Yogya (medical) are seen as models. The interuniversity center (PAU) at IPB, for example, started off as a World Bank funded project in the 1980s, but is now fully dependent on grants and contracts. Most grants come from the DG Higher Education, but there are also significant international grants (Korea, Japan, the Netherlands and the UK), as well as grants from the Ministry of Agriculture, and from the private sector.

Since the 1970s the Indonesia Ministry of Agriculture and IAARD have been very effective at establishing and maintaining **international research relationships**, especially through the Consultative Group on International Agricultural Research. The CGIAR has had a strong presence in Indonesia with a number of CGIAR Research centers, especially the International Rice Research Institute (IRRI), which has supported Indonesia's green revolution since 1972. Other CGIAR Centers with large programs include the International Potato Center (CIP) and the International Maize and Wheat Improvement Center (CIMMYT). Since 1996 Indonesia has been the home base for the Center for International Forestry Research (CIFOR).

Linkages between research organizations and **farmer organizations** have not been effective. The official KTNA farmer organization (established in 1971) was an instrument of the Suharto regime and was organized in a strictly hierarchical manner with representatives at provincial, district and local levels. It enjoyed significant support from the government, but lacked credibility and support of the farmers. Since the Reformasi era it has become more truly a representative of the advanced farmers – while it still enjoys government support in the form of office facilities.

Linkages with **NGOs** have been very limited in the past. IAARD mostly has rather negative views of NGOs. In terms of "distance" the two are far apart. "NGOs should understand their weaknesses" is a commonly heard opinion in the public sector – referring to the limited administrative and management capacity at NGOs, which can be explained partly by the fact that Indonesia does not have an NGO tradition. Under the Suharto regime NGOs suffered from repression and relationships were hostile. But since the beginning of the Reformasi period the number of NGOs has grown very rapidly. Linkages between IAARD and NGOs are now being facilitated with donor money. For the first time in 2003, NGOs became involved in a significant manner through a major Asian Development Bank funded Poor Farmer Project, with a USD70 million budget. This project was set up explicitly to target poor districts selected on the basis of a poverty mapping.

Before the 1997 financial crisis, which affected Indonesia more severely than any other Asian country, Indonesia was a fast growing economy and a major recipient of foreign direct investment. After the crisis companies have cut back on R&D activities and the number of partnerships with the **private sector** has decreased. Since 2004 they have been slowly recovering. In establishing linkages with commercial enterprises, IAARD's strategy has been not to compete with the private sector, but to seek areas of complementarity. For example in research on hybrid maize the strategy of the private sector has been to concentrate on areas with good soils, while IAARD's public mission has oriented the organization to work on marginal soils. Since 2002 IAARD has followed an explicit commercialization strategy and the number of partnerships with the private sector has grown to around 50 in 2007[76]. But often the private sector is not interested in working with public sector agricultural research.

[76] According to IAARD's website: http://www.litbang.deptan.go.id/mitra-kerja/swasta (accessed December 2007).

Problems cited relate to limited availability or relevance of IAARD technology, slow decision-making by IAARD, and the fact that intellectual property rights are not well guaranteed. The private sector prefers to subcontract research to universities, which are seen as more flexible than IAARD.

Direct linkages with the private sector consist of contractual relationships for specific assignments and services to be provided; there is hardly any longer-term and more structural collaboration. At the province and district level, one of the functions of the AIATs is to link with farmers groups, local agribusiness, and NGOs. While some partnerships and contracts have been established between the more dynamic AIATs and the private sector, on the whole this function remains weak.

IAARD as a public entity has difficulties to work in partnerships and to commercialize its research results, due to constraints for example on retaining revenues from commercial services. In response, IAARD has created a foundation (KP KIAT) for intellectual property and technology transfer, which can license technology and receive royalties (IAARD itself as a public entity is not allowed to do this). This unit has been in existence since 1999 and has developed only slowly.

IAARD has effective linkages with **policy makers**, based on close ties between IAARD and the Ministry of Agriculture. There is a long tradition of working together, which dates back to the concerted government effort to achieve self-sufficiency in rice production. Ministry of Agriculture monitoring of IAARD is frequent and senior staff rotate between the Ministry and the research agency.

12.3.4 Pakistan

Effective linkages between actors in agricultural innovation in Pakistan are constrained by the governance of the public administration system, as well as by the lack of operational budgets. Although the PARC/NARC research system is supposedly autonomous, in practice it is an integral part of the public administration system, characterized not only by extreme centralization of decision-making in the research system, but also by a severe lack of flexibility in operating arrangements. The use of contracts with third parties is very limited and there are no arrangements for research to become more market-oriented, e.g. to retain and reinvest any revenues from services provided to producers. Research, extension and education services are highly compartmentalized and cooperation between public and private sectors is almost non-existent. The second constraint is that … “more than 90% of the budget is allocated to salaries, leaving less than 10% for administrative expenses and operational costs.” (Greer and Husaini Jagirdar 2006: 5). Establishing and maintaining effective linkages between actors in the innovation system should be a key public responsibility. It is also relatively costly in terms of operational expenses for travel, workshops or publications.

NARC linkages

NARC linkages with a number of key actors in the agricultural innovation system were systematically reviewed during a series of linkage assessment and planning workshops involving staff from NARC and its (potential) partners. The workshops resulted in an analysis of the present situation and presented recommendations for new linkage partners, functions and mechanisms.

NARC linkages with **extension** and producer organizations (maintained through extension) are ineffective. “The weakest institutional link is the transfer or flow of higher production technology and packages from research institutes to agriculture extension providers, and onwards to the farmers” (Greer and Husaini Jagirdar 2006: 5). Linkages between research and extension have also become more tenuous over time. With the decentralization of a number of public services, including those for agricultural extension services, field staff now report to district administrations. “This has further weakened the chain of command of the respective directorates that were responsible for guidance, backstopping, and monitoring of the field staff and has added more complexity and risk to the implementation and management of development projects” (Greer and Husaini Jagirdar 2006: 5). NARCs options to improve this situation given its financial and governance constraints are limited and include training and information activities for the extension service.

Linkages with other **research organizations** include those with universities and with provincial research institutes. These are generally considered to be weak and are characterized by a lack of coordination between overlapping institutions, leading to duplication of research activities. There are no research coordination committees with effective stakeholder representation to plan and coordinate research with other organizations. Other weaknesses (and therefore options for improvement) include information exchange, especially sharing research findings with other research organizations and the distribution of information on training event opportunities and seminars.

Pakistan’s linkages with **international research organizations** have been mainly donor-funded and fluctuated strongly with changes in the political climate. In the Cold War period of the 1970s and 80s, Pakistan received strong support from the USA and other international donors. International support dropped after the Cold War had ended and reached a low after the nuclear test explosions of 1997 – to recover again when Pakistan became a key Western ally in the war on terror after 2001.

The country has been a major beneficiary of the green revolution in both wheat and rice. Pakistan has been an active participant in the Rice-Wheat Consortium, a collaborative research effort focused on improving productivity and sustainability in the rice-wheat farming systems of the Indo-Gangetic plains of Pakistan, India, Nepal and Bangladesh. The network is a partnership of five CGIAR research institutes (those involved in research on rice, wheat, potatoes, dryland crops and water management) and the national organizations in the four participating countries, mainly their public research institutes. Funding for this type of partnership is largely international, and without it R&D networks like this would not be able to function.

The analysis of partnerships during the stakeholder workshops showed that linkages with the **commercial private sector** are very weak. Main problems include the perceived lack of relevance of the research work by the private sector and an inability on the part of the research sector to engage in productive working relations with the private sector.

Collaborative work is effectively discouraged by the impossibility of research organizations to establish contractual arrangements with the private sector. New mechanisms to remedy this situation would be the implementation of joint research projects, the establishment of a foundation to fund research projects, and the commercialization of research results. Participation of the private sector in NARC research planning committees is another priority linkage mechanism. Linkages with NGOs are almost non-existent.

There are currently no direct linkages between NARC and **policy makers** with the exception of interaction on NARC's behalf by PARC. Some mechanisms have been established in the past, but are now defunct. This leads to a situation where NARC, which employs a number of highly qualified staff, cannot effectively contribute to agricultural policy formulation. Priority improvements are to re-establish an effective NARC Research Committee that incorporates representatives of government policy bodies (and donor organizations).

12.3.5 Sri Lanka

Sri Lanka's agricultural R&D system is small compared to that in the other countries in this study. Its key characteristic is the fact that even this small agricultural R&D effort is distributed over a large number of government ministries and agencies. The Sri Lanka Council for Agricultural Research Policy (CARP), established to coordinate and provide governance to this fragmented research system, is neither mandated to provide this governance role effectively, nor adequately equipped and staffed for effective coordination. The main research units in Sri Lanka are part of different ministries and generally do not have the flexibility or the instruments to engage effectively with other actors in the agricultural innovation system. There are differences between ministries though: the formerly private plantation crops institutes have more flexibility and better funding to support partnerships than the food crops research institutes under the Department of Agriculture.

CRI linkages

A series of workshops was organized by CRI and ISNAR in 2002 and 2003 to review existing linkage arrangements and to identify possibilities for improvement.

Linkages between CRI and **extension organizations** have been limited in number, and some mechanisms have become dysfunctional. CRI has a number of extension workers among its own staff who provide advice to producers directly, and who also respond to requests for information and assistance from other extension units. As in many countries, extension has been decentralized to the provinces – in Sri Lanka's case to eight Provincial Departments of Agriculture. In 1989 a political decision was taken to transfer the village extension workers from the Department of Agriculture to the Ministry of Public Administration as Village Officers. This led to the collapse of extension service provision at local level. Subsequent reforms have not been able to rebuild what was once a reasonably effective service (Mahaliyanaarachchi 2005). While the intention was to improve service provision to producers through decentralization, the effect has often been the opposite, as the provincial units lack competent staff and adequate funding to work with other organizations.

Even though CRI focuses on a clear target group and a single commodity, current linkages with **coconut growers and processors** are limited in effectiveness, according to workshop participants. Nearly all linkages are unilateral initiatives carried out by CRI. More effective relationships with the producers and processors can be achieved through the inclusion of producer and processor representatives in CRI's research priority setting and research program planning processes. Linkages with **other commercial enterprises** have also been limited in their effectiveness. Issues are the identification of problems of commercial enterprises and their technology and information needs, as well as the promotion of commercial enterprise involvement, and investment in coconut research and technology transfer. Linkages with **NGOs** have been a gap area for CRI with no effective linkages in existence.

Current linkages with other **national research organizations** have been moderately effective. The fragmentation of the research system and the limited coordination of research and development are causing problems in the area of sharing information on farmers' needs and technology relevance. CRI linkages with international research organizations and with donors are quite limited because coconut, as a non staple food crop receives very little donor support. While CRI's linkages with other actors are generally weak, it should be kept in mind that this is one of the better funded, more focused research institutes in Sri Lanka. It is reasonable to expect that the linkage situation of research institutes under the DoA is considerably more problematic still.

12.3.6 Vietnam

There are considerable differences between Vietnam and other countries in the study with regard to the organization of agricultural research linkages. In a review of the Vietnamese science and technology system Bezanson (2000: 13) observed that:

> "… the Vietnamese situation is complicated by the fact that, at present, the national R&D system is organised, financed and managed in such a way as to make the transfer of relevant information from research into technology both difficult and expensive. This is not unique to Vietnam. The research institutions in the country tend to follow a logic mostly inherited from a Soviet (mission-oriented) approach to the conduct of research activities, in which the end-user (the scientific community, educational institutions, a public agency) did not operate in the market. Research activities were identified in advance. There has been, until very recently at least, little awareness of the need to orient research activities towards the needs of the productive system. However, a few research institutes have been rather effective in obtaining contracts to provide technical services, usually applying well-known technologies, to government departments and state-owned enterprises. These linkages to the productive sector through contracted services to government agencies and SOEs appear to involve little genuine scientific research."

On the other hand, since the 1990s a number of policy initiatives were taken to strengthen the linkages between research and the productive sector. These include first, the freedom for research organizations to enter into research contracts with the productive sector. Second, according to Bezanson (2000: 19) research organizations were given "…much increased flexibility to develop and provide, in addition to research, a full range of services, including technology transfer, consulting services, experimental and pilot manufacturing, etc."

Crucially, and unlike most other countries, research institutes are allowed to retain profits from research or technology transfer activities. As discussed earlier, this may have led to crowding out of genuine research, but it has also created linkages with the productive sector for the provision of a number of knowledge based services.

A major change that has occurred since the year 2000 is a very significant increase in government expenditure on public R&D. A second change is the steep growth in FDI, which has had a number of impacts on agricultural innovation, most importantly the growth of agricultural support industries – these can and should replace the role that research institutes played in the supply of agricultural inputs when the market economy was much less developed. FDI growth is also transforming supply chains and the retail sector and inducing innovations in primary production.

NIAH Linkages
A more detailed assessment of linkages was undertaken for the National Institute of Animal Husbandry (NIAH), on the basis of a number of workshops held with staff from the institute and actors in its network. These included farmers groups, agro-industry, and universities. Meetings were also held with officials of the Ministry of Agriculture and Rural Development (MARD), and with the Ministry of Science and Technology (MOST).

Linkages with **farmers and farmer organizations** are rather limited and revolve around three functions: getting information from farmers on their technology needs (a mechanism judged by stakeholders to be ineffective), testing (where better methodologies and improved data quality are necessary), and dissemination of technologies and information through booklets and other information materials (judged to be modestly effective), or through direct farmer training, which is effective, but costly. NIAH plans to introduce new mechanisms, such as providing support to workshops organized by farmer groups themselves, establishing a Question & Answer service, and to improve farmer participation in technology development.

Agricultural extension in its modern sense is young in Vietnam and goes back only to 1993. Previously, under the centrally planned economy, farmers were instructed what to grow by the authorities. The linkages of public extension organizations with research and with other components of the innovation system are weak due to the rather low capacity of the extension agencies. The mechanisms used by NIAH include transfer-of-technology programs, extension worker training, obtaining farmer feedback together with extension, and joint technology evaluation.

NIAH linkages with **universities** are strong: it is fully integrated in the higher education system, though it does not belong to the same ministry as the universities. NIAH provides staff to the Hanoi Agricultural University to teach at both undergraduate and graduate levels. More importantly, NIAH provides research facilities and equipment for graduate students and expertise for the supervision of their research and dissertation. Other functions include: planning and coordination of joint research activities; training of graduate and undergraduate students at NIAH; collaboration in research and technology transfer; research evaluation; and sharing of equipment. The key mechanisms are exchange of staff (through consultancy contracts) and students, and sharing of equipment. Collaboration with **foreign universities and research organizations** is also quite strong and centers on four functions: getting new technologies, equipment and improved management methods; gaining international exposure; gaining access to up-to- date information; and providing opportunities to visiting faculty to learn about research issues in Vietnam. International research organizations also help NIAH in identifying sources of funding in developed countries.

NIAH linkages with **national policy makers** are related either to livestock research policy or livestock development policy. With regard to research policy the two main actors are MOST and the Department of Department of Science, Technology, and Quality Control (DSTQC) of MARD. The Department of Agricultural and Forestry Extension at MARD is important in livestock development policy. MOST influences the direction of agricultural research through its agricultural research program, composed of 14 national projects. These projects are drawn up by project advisory committees consisting of specialists on the subject matter and are reviewed at MOST by a national committee with leading agricultural scientists.

Linkages with **international donors** are very effectively maintained by NIAH. No other agricultural research institute in Vietnam has a comparable amount of foreign funding. At the workshops three key linkage functions in this area were identified: securing external funding for research, improving planning and design of projects, and sensitizing donors to livestock research and development issues.

Research relationships and research partnerships with the formal **private sector** are limited, as NIAH's research collaboration focuses on universities and international research institutes. A few projects on technology testing for private companies have been undertaken, but no structural relationships exist[77]. NIAH has traditionally been strong in providing services to a range of other clients including farmers, cooperatives and private enterprise. Services include ingredient and compound feed analysis; animal product analysis; livestock production advice; artificial insemination; and veterinary services. Though these are not the main task of NIAH, they have increased in importance since 1999 and they reflect a general trend for NIAH to become more development and producer-oriented.

12.3.7 An assessment of linkages

Table 12.2 presents a summary assessment of the strength and weaknesses of the linkages of the public agricultural research system in the four countries with the most important partners in the agricultural innovation system. A number of findings emerge from this linkage assessment:

First, partnerships in agricultural research, development and innovation are overall quite limited in number and in scope of collaboration[78].

[77] With the exception of NIAH's feed mill joint venture with a French company.

[78] Especially as the sample of organizations and individuals interviewed was biased in favor of collaboration, as contacts were made through the public agricultural research organization and focused on partner organizations with whom some familiarity and contacts exist.

Second, there are remarkable differences between the countries with regard to the overall effectiveness of the linkages maintained by public agricultural research actors. Pakistan has the most difficulty in maintaining adequate linkages, with Indonesia and Vietnam considerably more effective.

Third, partnerships in agricultural innovation function mainly where they are promoted through donor funding. Research organizations in Indonesia and Vietnam benefited considerably more from donor funding than Pakistan and Sri Lanka. Multilateral donors such as the World Bank and Asian Development Bank are important actors and play a key role in insisting that public sector research organizations engage with other organizations.

Fourth, donor pressure, changing government policies, more open markets, and decentralization contribute to public research actors becoming more receptive to the need for working in partnerships. But it requires a change in attitude of researchers and managers in public research organizations who have functioned in a highly centralized and hierarchical system for most of their careers. More importantly, it requires changes in decision-making processes, allowing horizontal interactions to happen.

Finally, as long as linkages and partnerships depend on donor funding they will not be sustainable. At the same time, national research organizations which do not have adequate operational budgets for their research staff, can hardly be expected to make funding available for networking with other organizations.

Table 12.2 Assessment of linkages between public agricultural research organizations and other innovation actors

Country	Indonesia	Pakistan	Sri Lanka	Vietnam
Function				
Extension	—	— —	—	—
Farmers	—	— —	+/—	+/—
Private sector	—	— —	+/—	+/—
Research organizations	+	—	—	+
International Donors	+	+/—	—	++
Policy makers	+	—	—	+
NGOs	—	—	—	—
Score	13	5	9	16

++ very strong (4 points), + strong (3 pts.), +/— moderate (2 pts.), — weak (1 pt.),
— — very weak (0 pts.)

Source: interviews and stakeholder workshops

12.4 Agricultural innovation networks, paradigms and innovative performance

12.4.1 Country innovation performance

There are marked differences between the linkages in the agricultural innovation systems in the four countries studied – as discussed in previous sections and summarized in Table 12.2. Similarly, the countries differ to the extent that they have adopted combinations of the four different agricultural innovation paradigms. This section relates both the nature of linkages and networks, and the adoption or penetration of the different innovation paradigms to the overall performance of the (agricultural) innovation system and the agricultural sector, which was analyzed in Chapter 8 above.

Chapter 8 presented two composite rankings of innovation, one based on a set of agricultural productivity growth rates, and the other on a set of technological development indicators. The two rankings are summarized in Table 12.3, from which it is clear that the two Southeast Asian countries are outperforming the two countries in South Asia. Vietnam's overall agricultural innovation has been fastest of all four countries (and indeed one of the fastest in the world). The fact that Indonesia has a higher score on the technological innovation index is explained by the fact that Indonesia has had a much longer history than Vietnam in investing in science, technology and innovation (the index covers the period the mid 1990s to 2004). Since the beginning of the 21st Century, Vietnam's expenditures on science, technology and innovation have expanded more rapidly than those of Indonesia. Differences with Pakistan and Sri Lanka are considerable, with Pakistan's agricultural productivity growing at a higher rate than Sri Lanka's and both countries showing equally low rankings in the area of technological innovation.

12.4.2 Networks and innovation performance

The linkage and network performance of the research organizations in the four countries as presented in table 12.2 corresponds closely to the innovation scores in Table 12.3. Does this confirm the hypothesis that innovation networks are a precondition for innovation? Or, conversely, does innovation lead to better networks? Or, can both phenomena be explained by a third variable that drives both innovation and network formation? In this section the argument is developed that, at an **operational** level, networks are a condition for innovation, but that innovation also improves further network integration. The next section argues that, at a more **strategic** level, both agricultural performance and the functioning of innovation networks can be explained, at least partially, by how countries have been able to adopt different agricultural innovation paradigms, each with their own linkage characteristics.

There are strong indications in the literature reviewed in this study that effective linkages are a condition for innovation. In the past, large individual organizations could cover the entire knowledge chain within the boundaries of the company or institute, but this is increasingly an exceptional situation. These days, even large MNEs are discovering that they cannot cover the entire knowledge chain on their own and are moving towards open innovation models. In agriculture innovation has always involved a variety of actors as individual production units are small and dispersed in location. The overwhelming majority of innovations discussed in the four different paradigms originate from outside the farm where they are eventually applied in original or adapted form. Necessarily, this requires linkages between actors in the innovation system.

Table 12.3 Summary innovation indices per country

Country	Agricultural innovation score	Technological innovation score
Indonesia	19	15
Pakistan	11	7
Sri Lanka	7	7
Vietnam	23	11

Source: Tables 8.4 and 8.10

Linkages are seen by research organizations in all four countries as a major weakness, but big differences can also be observed. Specifically, agricultural research organizations in Vietnam have been encouraged to establish close links with the productive sector and have been allowed to retain revenues obtained from such activities, thus stimulating researchers to maintain contact with farmer groups and help solve their problems. While this has been often done at the expense of more formal forms of research, it has served the agricultural sector well – at least during the early stages of agricultural development.

Indonesia has had more formal agricultural research system with less close linkages at individual researcher level with farmers, but the country has developed a large research infrastructure. Since the 1980s when achieving self sufficiency in rice production was the key legitimization of the Suharto New Order government, there have been effective top-down linkages between different branches of national and local government involved in agricultural development. With the radical decentralization process undertaken since the beginning of Reformasi era, this situation has been turned upside down. At this moment Indonesia is still struggling to find a new balance and to develop effective innovation linkages in a decentralized context.

Pakistan’s recent agricultural growth has been impressive, but it was caused not so much by the establishment of effective linkages between agricultural innovation actors as by the removal of the most severe policy biases against agriculture (biases already removed earlier in Southeast Asia). This led to a number of relatively easy gains, but to raise agricultural productivity to the next level will require both further structural reforms in the sector and much better flows of information and technology. Here Pakistan does not look well placed as the assessment of its own researcher managers indicates very major problems.

Finally, Sri Lanka’s problem in establishing effective linkages between agricultural innovation actors is caused both by a total fragmentation of agricultural research and extension in the public sector, as well as by limited private agricultural innovation activity. This is the result of structural rigidities in the agricultural economy, which remains largely stuck in the production of a number of traditional commodities: tea, rice, coconuts and rubber.

So while linkages between organizations determine the potential for agricultural innovation, it is also obvious from information presented above that (certain types of) innovation promote further linkages and the formation of specific types of innovation networks. Complex farming systems have developed in Asia since historical times, but (with the exception of colonial plantation crops) these were based essentially on local and regional relationships. Modern agricultural production systems rely increasingly on national and international relationships, and it is clear that innovation breeds new linkages as it requires specialization and (re)combination of production factors. Supermarket chains in Indonesia and Vietnam are establishing sophisticated linkages with local and international suppliers and customers. These structuring effects, which lead to more sophisticated innovation networks, are much less developed in Sri Lanka and Pakistan.

12.4.3 Paradigms, networks and innovative performance

The innovation paradigms are characterized by different and paradigm-specific types of networks. Green revolution networks are publicly oriented and, if anything, suffer from overembeddedness. Sustainability networks are learning types of networks, which involve more open communities of practice. The strategic alliances related to the biotechnology paradigm require advanced linkages between companies, governments and academia in relation to capital, regulation and safety, and on intellectual property. Supermarkets and food companies can play a major role as actors in building or restructuring innovation networks.

Indonesia has been an early adopter of the green revolution, which was promoted very extensively through a number of national and international programs. Seeing the problems of ever more intensive agriculture in rice production, the country also became an early adopter of sustainable approaches, especially the IPM program. Indonesia is also ahead of other countries in dealing with genetically modified crops. As a large, relatively open country it is an attractive market for life science companies. The same applies to the supermarket revolution: Indonesia has moved ahead faster than any of the other countries in this study. As such, Indonesia is actively engaged in all four paradigms and has developed a range of both national and international networks. Its main weakness is related to the limited effectiveness of its public sector research and extension system in developing innovation networks,

Pakistan's agricultural economy has opened up since 1997, when a number of policy constraints were removed. It has widely adopted green revolution technologies in rice and wheat and is implementing sustainability practices – though on a much smaller scale than Indonesia. Biotechnology work is limited to some research undertaken in the public sector, and the presence of private life sciences companies is very small. There are no effective linkages based on the biotechnology paradigm. Despite its size and relatively good performance on business regulation indicators Pakistan is not yet a very attractive country for supermarket chains, and their impact on agricultural innovation is negligible.

Sri Lanka has a relatively closed economy (for its small size). Its adoption of green revolution technologies has leveled off, like Indonesia. Adoption of sustainable practices is taking place, promoted amongst others by government and NGOs. Progress in biotechnology is very limited and international supermarkets, food and biotechnology companies and are not represented in the country. As a result, Sri Lanka is missing a big opportunity in becoming an export-oriented agricultural economy based on new high value commodities.

Vietnam was a late adopter of green revolution technologies, but its use of inputs is now very high and perhaps unsustainable in a number of cropping systems. Quantitative production goals (emphasis on rice and coffee exports) still dominate the agricultural economy. But Vietnam is also adopting sustainable technologies as evidenced by the large number of farmers trained in IPM. Direct experience with biotechnology is more limited than Indonesia but the government is expanding its investment in science and technology rapidly and life science companies such as Monsanto are represented in the country. Also, Vietnam is moving ahead in the adoption of international regulation: it is the only country to have signed the most recent version of the UPOV agreement on plant breeders' rights. Vietnam has the most open economy of the four and while incomes are still low and presence of modern retailers is still limited, this picture is changing very rapidly. The Government of Vietnam remains actively involved in agricultural development and in the establishment of innovation networks, for example by encouraging international supermarkets to work with groups or cooperatives of small farmers.

What can be observed is that all four countries have developed green revolution networks, and that these have indeed become primordial networks – structuring network interaction involving a limited number of public sector actors. To a certain extent all four have also adopted the sustainability paradigm, often as an add-on to the green revolution. But while Indonesia and Vietnam are expanding rapidly in adopting agri-food chain based innovation and to a more limited extent biotechnology based innovation, Pakistan and Sri Lanka, mainly for institutional reasons, have not yet managed to make that transition, a situation that is largely responsible for their slow improvements in agricultural innovation performance.

13. Conclusions and recommendations

This study set out to address three main research questions:

1. What different agricultural innovation models or paradigms have emerged, and how have these paradigms developed from the interaction of driving forces and innovation actors?
2. How do the different drivers, innovation actors, processes and paradigms perform in Asia?
3. How can agricultural innovation actors interact more effectively in networks, given the constraints imposed by different paradigms, and what policy measures can be taken to promote agricultural innovation?

This chapter provides conclusions and recommendations for policy. First, in 13.1 it discusses these in relation to the four techno-institutional paradigms and the drivers that shape these paradigms. Next, in section 13.2, conclusions and recommendations are presented for actors and networks of actors, taking into account that there is a close relationship between paradigms and types of networks. Conclusions and recommendation for the four countries in this study are presented in 13.3. Finally, this chapter discusses the value added of the study, its limitations and implications for further research (section 13.4).

13.1 Agricultural innovation paradigms and drivers

This study analyses how technologies and institutions co-evolve and are developed, adapted, disseminated to and adopted by actors. Combinations of technologies, institutions and actors lead to the emergence of different techno-institutional paradigms. Techno-institutional paradigms are characterized by a dominant technology and a related set of institutions and often characterize an entire period (e.g. the steam age). When new techno-institutional paradigms emerge, older models may become obsolete and disappear. But often, competing paradigms co-exist at the same time and compete for dominance – as is the case in agriculture.

The key conclusion from part I of this study is that agricultural innovation is not only an interactive process involving a variety of public and private actors. More fundamentally, agricultural innovation encompasses a number of entirely different – often rival – techno-institutional paradigms. These arose at different periods of time, are dominated by different actors and are based on fundamentally different technologies and institutional arrangements. They create a particular ‘selection environment’ for technological and institutional change trajectories, and thus ultimately also for the performance of the innovation system. Agricultural innovation can only be properly understood when these different paradigms are taken into consideration in conceptual and empirical research.

The study shows how four techno-institutional paradigms result from the interaction of two types of actors (public and private) and two different dominant drivers (technical and institutional change). Two paradigms originate mainly in the public sector: the green revolution and the sustainability paradigm. The green revolution's seed-fertilizer packages of technology resulted from technological breakthroughs; the sustainability paradigm, which besides public organizations also involves civil society, was based largely on institutional changes, including new management models and practices. The agri-food chain paradigm and the biotechnology paradigm are driven by the private sector. Whereas the agri-chain paradigm is based mainly on institutional and organizational drivers (FDI, logistics, supported by information technology), the biotechnology revolution is driven largely by genetic modification technology.

The techno-institutional paradigms are based on three innovation drivers: internationalization, technical change, and institutional change. Internationalization affects agricultural innovation both directly, as well as indirectly through its effects on new technologies and institutions. Starting with the spice trade in the 16th Century, Asian agriculture has been strongly influenced by developments at the other end of the globe. But the present wave of globalization that began with the outsourcing trend in the 1980s is of a new dimension. Driven by dramatically falling communication and transportation costs and facilitated by more liberal trading regimes, globalization is no longer limited to spices, sugar, coffee, tea and palm oil, but affects production, trade and consumption of both traditional staple crops such as rice and maize, as well as new products such as fresh fruits and vegetables, and fish and shrimps.

New technologies and technical innovations can have their origins in many different sources. Private companies, universities, public (agricultural) research organizations, and individual farmers develop and disseminate new products, practices and processes. There is a long-standing debate whether innovation is largely driven by new developments in science and technology or by market dynamics. Both sides are supported by empirical evidence and a consensus has emerged that innovation is an interactive process which needs to involve different types of actors, institutions (including markets), and technologies.

Institutional change as a driver of innovation is also increasingly influenced by changes at the global level. New institutions governing world trade, a global strengthening of intellectual property rights and emerging global standards for food quality and safety are becoming key drivers of agricultural innovation in developing countries. Examples of new institutions needed at national level are those that deal with physical and intellectual property, banking and finance, and more specifically regulatory bodies that deal with agriculture and food. At the local level there is a need for effective farmer organizations, rural credit institutions, and new organizations that support learning such as farmers' field schools. At present, at the national level in most developing countries, institutional environments for agricultural innovation are determined by rigid, hierarchical structures and processes, with very little flexibility to adapt to changing circumstances. Institutional change, as Nelson (2007) observes, is much more difficult to achieve than technical change and forms the most important obstacle to agricultural innovation.

A number of specific recommendations may be given in relation to techno-institutional innovation paradigms, technological development, institutional development and internationalization:

1. To be effective, specific innovation strategies need to be developed for each of the four techno-institutional paradigms. Green revolution technologies and sustainable agriculture, although “old” paradigms, require maintenance research to ensure that technologies at the end of their life cycle are renewed and that evolving pest and disease problems can be adequately addressed. Sustainable agriculture issues – at present also in the shape of the “bio-based economy” require different types of strategies and networks. In biotechnology, key issues relate to regulation, access to science, and risk perception and assessmrnt. The agri-food chain paradigm is characterized by the dominant role of standards and quality assurance.

2. Agricultural technology development strategies should involve a range of possible actions including acquisition, development and dissemination of technologies. What technologies to make, buy, or borrow is an important strategic question for agricultural research organizations and other innovation actors.

3. Key institutional issues are related both to incentives and to the need to provide an effective institutional framework. Incentives are needed to ensure that public research organizations, seed companies and other agri-food chain actors focus on the delivery of services to and the participation of small farmers. The national institutional framework needs to be able to deal effectively with issues related to IPR, biosafety, food safety, and the role of quality standards.

4. To benefit from internationalization in agricultural science and technology, national agricultural R&D organizations need continuous (and increased) investment in scanning, understanding, assessing and accessing technologies developed elsewhere. This requires not only technology assessment skills, but also an understanding of the new regulatory framework under WTO and other international organizations.

13.2 Innovation actors and networks

Individuals, organizations and networks make innovation happen and a large number of actors are involved in the agricultural innovation process – both from the public and the private sector. Innovation networks provide opportunities for cooperation not available in markets or in hierarchical organizations, because networks provide both flexibility and a set of rules (institutions) that govern the interaction between partners. Networks come in many different types and configurations and range from very informal configurations to tightly integrated networks, such as supply chains based on contractual arrangements. Networks also differ with regard to the embeddedness of actors. Four types of innovation networks were presented in this study: organizational networks, communities-of-practice, supply chains and strategic alliances.

These network configurations correspond directly to the four techno-institutional paradigms: the green revolution model conforming to the organizational network, the sustainability paradigm following the community of practice model, the agrifood chain network corresponding to the supply chain model and the strategic alliance is the most prominent network in the biotechnology paradigm.

Public agricultural research organizations and networks have been successful in the introduction and dissemination of green revolution technology packages in largely homogenous (irrigated) production areas in Asia. This was the result of a clear vision of the need to achieve food security in the 1970s and 1980s. But in general research organizations have not well adapted to a more complex institutional situation.

At present, networks in the green revolution paradigm are characterized both by overembeddedness and underembeddedness, with the latter the more severe problem because of ineffective relationships with extension, farmers, processors and retailers. Neither cooperation, nor competition work particularly well in this paradigm, the former as a result of compartmentalization of public sector organizations, and the latter due to a lack of incentives to produce high quality technologies relevant to farmer needs. The agricultural research councils established in a number of countries (Sri Lanka, Pakistan) in order to integrate the different stakeholders are not working well, as their participation is limited to a narrow range of public sector research actors.

The main recommendation for public research actors is that they need to improve their capacity to link (with other innovation actors) and learn (how to solve producer problems). To work more effectively with other actors it is important to reduce compartmentalization and fragmentation within and between public sector actors in the agricultural innovation chain by integrating research, extension and education function much more tightly.

Community-of-practice networks involve a number of actors to address sustainability issues. These include farmer groups, NGOs and sometimes private or public R&D actors and others in the chain. CoP networks integrate organizations with a deep understanding of producer problems and environmental issues, local production systems and technologies. Linkages between these actors are however often complicated because of different interests, objectives and agendas. Specific measures to improve linkages between NGOs, farmer organizations and other actors in the agricultural innovation system need to focus on building trust between NGOs and public research organizations. This can be done through a number of specific mechanisms such as the involvement of producers and NGOs in public sector research planning and priority setting, and in participatory research and technology development. There is also a need to develop capacity building programs to farmers to make the transition to the agricultural knowledge economy and to improve local capacity to evaluate new technologies and practices.

Private sector seed and biotechnology companies are seeking new markets and increasing their investments in developing country agriculture, especially in Asia. They strongly rely on dissemination of proprietary technologies protected by plant breeders' rights, patents, trademarks or characteristics embodied in the technology itself (e.g. hybrid seeds). They are usually exploiting broadly applicable technologies developed in their home base. Locally, they rely on their own marketing and extension units to commercialize their seed-fertilizer-agrochemicals packages. Measures that may be taken to improve linkages of private sector seed and biotechnology companies in agricultural innovation systems include the promotion of public-private innovation partnerships or foundations based on best practices internationally, and the establishment of channels to promote the exchange of proprietary (bio)technology between public and private research actors. Private companies should be encouraged to establish corporate social responsibility programs to support marginal producers; this may done together with the provision of fiscal and other incentives for private agricultural R&D.

Retail chains and agri-food chain networks play a growing role in agricultural innovation in Asia. They are transferring new production technologies and standards through the agri-food chain to upgrade production systems and to ensure reliable supplies of high quality products for their processing or for retail. They play a key role in reorganizing the supply chain, by establishing regional distribution systems and direct relationships with producers through contract farming arrangements and the introduction of quality standards that suppliers must comply with. Policy measures to improve the linkages of retailers and food producers with other actors in the agricultural innovation system include the introduction of quality and safety standards in such a manner that small producers may participate in modern quality assurance schemes. This requires research, training and information exchange on best practices in agri-food chain upgrading, with an important role for public research organizations. Policy dialogues between agribusiness and producer organizations and government agencies are needed to identify constraints and opportunities and promote joint R&D activities.

13.3 Drivers, actors and paradigms in Asian agriculture

Part II of the study analyzed agricultural innovation processes in Asia at a number of levels: starting with macro level agricultural sector and innovation system performance and proceeding to the performance of drivers, paradigms, networks and innovation actors. Specifically, the study analyzed the different performance types for four countries, seeking explanations for differences and similarities encountered, as well as aiming to derive overall conclusions.

Agricultural sector and innovation system performance

The study concluded that agricultural sector performance has generally been high in Asia, but that major differences exist between the countries studied. An agricultural sector performance ranking based on productivity changes in major commodities, labor productivity, and agricultural exports, indicates the highest performance levels for Vietnam and Indonesia, with substantially lower rates for Pakistan and Sri Lanka. This picture is repeated in the ranking of selected innovation indicators. Interestingly, agricultural sector and innovation system performance as presented in the ranking for the countries studied is not in line with country scores on a number of widely used governance and (ease of doing) business indices developed by the World Bank. Domestic institutional quality as measured by governance and development indicators, therefore, does not appear to explain performance for the agricultural sector and for innovation systems. Two explanations are offered for this discrepancy. One is that the indices require a small-government, deregulated economy for high scores, while institutional quality for agricultural innovation depends on effective public services to support the process and facilitate interaction. A second explanation is that most “governance” and “business climate” measures are more geared towards the industry and services sectors than to agriculture.

Innovation drivers

An analysis of the performance of the three innovation drivers also shows big differences between countries in Asia. Internationalization as manifested by trade and FDI manifests itself quite differently in the two Southeast Asian and the South Asian countries, with the former two showing a much higher inward FDI potential. Technical change, based on indicators such as the use of technical inputs, adoption of IPM, and biotechnology uptake point towards early adoption by Indonesia, rapid recent technical change in Vietnam, and more modest changes in Sri Lanka and Pakistan. Institutional change indicators (of which there are only a few) show a mixed picture.

Techno-institutional paradigms in different countries

The conclusion is that different paradigms are represented in the four countries in rather different ways. The oldest of the four paradigms, based on the green revolution has a strong presence everywhere, and this applies to sustainability as well. But while sustainability concerns are now fully integrated in the agricultural research agenda in most countries, this does not translate readily in more sustainable production systems. The reason for this is that both the physical production environment as well as the institutional selection environment to create more sustainable systems is much more complex than production systems and selection environments at the time of the green revolution – the latter characterized by relatively homogeneous lowland production systems and relatively simple institutional structures prevalent at the time when the green revolution was introduced.

There are more salient differences with regard to how biotechnology and agri-chain paradigms present themselves in the four countries. Biotechnology is still largely a potential innovation paradigm as regulatory restrictions have so far prevented the widespread dissemination of GM crops in most Asian countries. The main potential to benefit from biotechnology is found in Indonesia (as a result of market size) and Vietnam (because of strong government support). It is much less present in the other two countries due to limited FDI in both, and a small market size in Sri Lanka. With regard to the agrifood chain paradigm Indonesia and Vietnam have become important countries since 2000 because of market size and expected opportunities respectively. Pakistan is catching up, but in Sri Lanka supermarkets, as yet, play a very minor role. Table 13.1 presents a summary of the presence and importance of the agricultural innovation paradigms in the different countries.

Innovation actors

Public and private actors play quite different roles in Asian agricultural innovation. Public sector agricultural research continues to be the core actor in agricultural technical innovation with more than 90% of R&D expenditure. The size of private agricultural R&D remains very small and there are no data on innovation activities led by non-research actors, such as supermarkets. Public sector agricultural research organizations are severely limited in playing a more strategic role in the agricultural innovation system because of serious governance, funding and staffing problems. Public sector agricultural research organizations remain vertical hierarchies dominated by centralized top-down decision-making and an almost complete lack of effective horizontal relations with non-government actors. As a result the performance of public agricultural research organizations has suffered – most importantly through the absence of effective linkages with other innovation actors, especially in the private sector.

Table 13.1 Presence of the innovation paradigms in the four countries

	Green Revolution	Sustainability	Biotechnology	Agri-food chains
Indonesia	H	H	M/H	H
Pakistan	H	H	L	L
Sri Lanka	H	H	L	L
Vietnam	H	M	M	M/H

(H= High, M= moderate, L=low)

Private agricultural innovation includes a wide variety of actors (e.g. seed, agrochemical and biotech companies, machinery manufacturers, food companies, and supermarkets), which are playing an increasingly important role in agricultural innovation. Although their share in agricultural R&D spending in developing countries in Asia has remained well below 10% they contribute in a number of other ways to innovation. Seed companies disseminate high quality input packages to farmers. Supermarkets and food companies aim at upgrading the agricultural supply chain through logistics (direct sourcing) and the application of production standards to ensure high and consistent quality and reliability of supplies. Agrifood chain-based agricultural innovation is most advanced in Indonesia, where in some parts of the country a new class of entrepreneurial farmers has emerged. Indonesia's lead is followed by Vietnam with much slower change in Pakistan and Sri Lanka. Overall, the non-research contribution of private actors to agricultural innovation has not been well researched and little information is available as to its importance.

Networks of public and private actors form the basis of the agricultural innovation process. Two main conclusions are drawn in relation to agricultural innovation networks. The first is that specific network types correspond to each of the four paradigms, and as a result interaction patterns differ significantly between paradigms. Second, agricultural innovation systems in Asia are characterized by network failures as a result of both overembeddedness and underembeddedness in different types of networks. Public agricultural research organizations need to play an important role in the integration of actors in networks, but their weakness is precisely their inability to perform this role. Public agricultural research organizations in Sri Lanka and Pakistan have the most serious problems in relating to innovation actors outside the narrow domain of public R&D. In Indonesia the situation in improving as IAARD is gradually opening up to other actors, and in Vietnam the role of public institutions and policies in agricultural innovation remains strong.

Table 13.2 Indonesia: Summary of paradigms, network characteristics, performance issues and challenges

Paradigm	**Importance, Presence**	**Networks and linkages**	**Key performance issues**	**Challenges**
Green Revolution	H	Public national IAARD network and decentralized AIATs. Strong international linkages. Few linkages with private sector. Limited but growing NGO and stakeholder involvement.	Coordination issues between national and local level public R&D Public-private linkages	Open up networks to include a wider range of actors Improve national – regional – local coordination
Sustainability	H	Integrated in IAARD Emerging linkages with NGOs International participation	Weakness of linkages with local groups and NGOs	Strengthen role of local actors and informal networks
Biotechnology	M/ H	Presence of biotech companies Public research effort in biotech Limited public – private interactions Vocal NGOs	Attractive, large market, but government policies not very conducive Public opinion on GM issues	Improve regulatory framework Increase transparency Encourage societal debate
Agri-food chains	H	Strong presence of national and international (export) networks	Strong presence in parts of country. Small number of modern producers	Extend participation to small producers, involve farmer groups

Tables 13.2-13.5 present, for the different countries, summary characteristics of paradigms, networks, performance issues, and challenges. In Indonesia's agricultural innovation system (table 13.2) green revolution technologies play an important role in strong public R&D networks, which have now both national and provincial components. Linkages with other actors are weak, but improving. Sustainability concerns are well integrated in the research agenda and addressed through the network of regional technology assessment institutes. Indonesia has a more elaborate network of actors involved in the biotechnology paradigm than the other countries. It includes private companies (international and national) and public organizations (research and regulation). Biotechnology innovation is, however "on-hold". Compared to leading developing countries (Argentina, Brazil, China) there is little actual biotechnology innovation in Indonesia at present, though policies and regulatory frameworks are in place. If the rapid growth in biotechnology applications is spreading more widely in

Asia, Indonesia is well placed to benefit, provided it handles public concerns over safety issues in an adequate manner. For Indonesia the most important policy recommendations are:

1. Improve significantly external linkages with the private sector (national and international), and internal coordination in the public agricultural research system (national and provincial) to deliver services to farmers.

2. Develop clear policy guidelines for biotechnology. Improve the regulatory framework, strengthen the capacity to take up biotechnology innovations, and build trust based on transparency.

3. Provide support for national agribusiness to engage in agri-food chains. Build on existing capacity to strengthen involvement in international food chains. Extend agri-food chain based innovation beyond Java to the outer islands. Focus on involvement of small farmers in agri-food chains.

Table 13.3 Pakistan: Summary of paradigms, network characteristics, performance issues and challenges

Paradigm	Importance, Presence	Networks and linkages	Key performance issues	Challenges
Green Revolution	H	Hierarchical PARC/NARC network at national level Provincial Research Networks No linkages with private sector	Lack of national-provincial coordination Absence of NGO linkages	Reform governance of public research system Improve coordination, networking
Sustainability	H	Integrated in national and regional efforts International: rice-wheat system network	Weakness of linkages with local groups and NGOs	Strengthen role of local actors and informal networks
Biotechnology	L	Limited biotech network development	No FDI in biotech Limited national public effort	Attract private investment
Agri-food chains	L	Limited presence of national and international agrifood chains	Limited FDI or national investment in agri-food chain improvement Limited food chain related innovation, e.g. upgrading practices	Encourage establishment of food chains by private sector. Build export chains

In Pakistan (table 13.3) the public agricultural research system consists of separate national and provincial public R&D networks, with limited interaction between them. There are also very few linkages with other innovation actors. Sustainability networks are integrated with public research and supported by international donors. Biotechnology is as yet limited to some investment by public research institutes such as NARC and the University of Agriculture in Faisalabad. A National Commission on Biotechnology, appointed by the government, is advising on policy and regulations. Private sector investment in biotechnology has remained limited. Investments in upgrading agri-food chains (for domestic retail, or export agriculture) have also remained very small in comparison to other countries. For Pakistan the most important policy recommendations are:

1. Restructure the public sector agricultural research at national and provincial level to ensure effective linkages and flows of technologies and information.

2. Establish policies, an appropriate regulatory framework and incentives to attract biotechnology foreign investments. Improve national public capacities in biotechnology. Build national networks and strengthen international links.

3. Promote export-oriented agri-food chain development based on high-value fresh product for nearby markets e.g. in the Middle East. Introduce and support quality standards. Encourage private investment in agri-food chain development

Table 13.4 Sri Lanka: Summary of paradigms, network characteristics, performance issues and challenges

Paradigm	Importance, Presence	Networks and linkages	Key performance issues	Challenges
Green Revolution	H	Ag. R&D under six different Ministries Ineffective steering, lack of coherence in policies	Lack of policy guidance Fragmentation of public research	Overhaul governance of public research system
Sustainability	H	Integrated in national level research Strong NGO activities to promote sustainable development	Weakness of linkages between research and local groups, NGOs	Strengthen networks and linkages
Biotechnology	L	No presence of biotech companies (small unattractive market) Very limited national capacity	No biotech FDI Weak public biotech capacity No biotechnology policy No regulatory framework	Attract funding for a limited biotechnology effort
Agri-food chains	L	Very limited presence	Absence of food chain related innovation, e.g. upgrading practices	Encourage establishment of food chains by local private sector Build export chains

In Sri Lanka the public research system is fragmented, with little national coordination and lack of effective steering. Linkages with other actors are weak. Sustainability concerns are addressed in public agricultural R&D, and civil society organizations are actively involved in networks aimed at improving sustainable agriculture. Biotechnology is undeveloped – there is no effective national policy and no regulatory framework. The reasons for this are first, that Sri Lanka is a small market, which does not attract investments in biotech; and second, that public efforts suffer from low funding levels of agricultural R&D. The only important export value chain is tea – otherwise Sri Lanka has not engaged in developing new high-value export networks. At the national level supermarket development is quite limited with no presence of international chains. For Sri Lanka important priorities should include:

1. Improve the effectiveness of the public agricultural R&D system by reducing internal fragmentation and strengthening coordination between research actors, and especially with farmer groups, private sector and NGOs.

2. Promote the development of national and international agri-food chains. Extend value chain experience in some commodities (e.g. tea) to others. Promote participation of small farmer groups.

3. Build national biotechnology networks with universities, so that the country can benefit from technologies developed elsewhere.

In Vietnam the Ministry of Agriculture and Rural Development is directly responsible for agricultural research and innovation. It has overseen a major effort to turn Vietnam into an exporter of food crops. Internal coordination is strong and linkages with other innovation actors are relatively well developed at operational level. Sustainability concerns have until recently received relatively low priority, but strong donor support to agricultural innovation and the recent emergence of civil society organizations ensures that sustainability concerns are becoming more prominent. The Vietnam government is aggressively expanding the national science and technology budget, which will have a strong impact on biotechnology capacity. This will position Vietnam rather well to engage further in biotechnology development. The country forms a large and attractive market and already has a significant presence of international seed and life sciences companies. As a leading global agricultural exporter Vietnam has built a strong presence in global value chains, which have induced innovation and upgraded production standards in important commodity chains such as rice, coffee, fruit, flowers and seafood. At the national level food chains are not yet as well developed as those in Indonesia due to the fact that Vietnamese incomes are still low by Asian standards and that supermarkets have only recently taken off. This is however likely to change rapidly in the near future. Recommendations for Vietnam are the following:

1. Improve sustainability of agriculture by encouraging local and civil society actor involvement in networks of agricultural development and innovation.

2. Move towards advanced biotechnology applications based on strong national investment. Improve regulatory framework for investment, safety and transparency to stakeholders.

3. Extend successful agri-food chains and networks by focusing on quality, (small) farmer education and effective information systems.

Table 13.5 Vietnam: Summary of paradigms, network characteristics, performance issues and challenges

Paradigm	Importance, Presence	Networks and linkages	Key performance issues	Challenges
Green Revolution	H	Ministry dominated model Coordination through national programs Geographic concentration in river deltas Strong export networks Strong linkages with producers	Strong production orientation in intensive cropping systems in the Deltas	Improve sustainability of food production system Diversification to higher value crops
Sustainability	M	Some restrictions on NGO activities Increasing importance, but from a low level, due earlier emphasis on production growth	Limited formal involvement of NGOs in research, but strong linkages with farmer groups, cooperatives	Strengthen public efforts in both lowland intensive production systems and in highland fragile farming systems
Biotechnology	M	Recent presence of biotech companies Public push in biotech Some public-private interactions	Limited public-private interaction in biotech Elaborate policy framework	Build public private partnerships Increase transparency Encourage public debate
Agri-food chains	M/H	Strong presence of international (export) networks Expansion modern domestic retail (from low base)	Agri-food chains favor larger, more modern producers	Involve small producers in food chains

13.4 Value added of the study, limitations and implications for further research

This final section assesses the value added of this study, its limitations and identifies possibilities for follow-up studies.

13.4.1 Value added of the study

This study has contributed to the understanding of agricultural innovation in Asia in a number of ways.

First, building on the idea of agricultural innovation is an interactive process and on the notion that innovation requires the co-evolution of institutions and technologies this study advances the understanding of agricultural innovation by showing that it needs to be seen as composed of a number of different techno-institutional paradigms. The study elaborates four different paradigms, following from four different revolutions which are driven by distinct actors and different technical and institutional innovations. The study shows that incremental within-paradigm innovations can be distinguished from more radical innovations at the interface of paradigms. The study also shows that these paradigms can be directly linked to different types of innovation networks with different core actors and different relations between them.

Second, the study tested this agricultural innovational model in Asia using a wide variety of data and information, and linking different levels of analysis. In doing so, the study confirmed that actors, institutions and technologies relate in unique ways to different paradigms. The study also showed that countries differ in how they perform in relation to drivers, actors, networks and the effective adoption of paradigms. Actors may participate in different paradigms at the same time, but they will play different roles in each.

Third, while most studies in practice restrict innovation to R&D (and frequently to R&D expenditures), this study analyzed a broader range of indicators across different levels of analysis and countries. The drawback of this approach is that the data for the study remained relatively fragmented.

Fourth, this study provides policy recommendations linked to different paradigms, types of actors and countries. The study shows that innovation policies can be made more effective by viewing innovation first as an interactive process; second, as the co-evolution of technological and institutional change; and third as including fundamentally different paradigms, for which different recommendations should be made.

13.4.2 Limitations of the study and issues for further research

The approach chosen necessarily has a number of limitations – some of these suggest avenues for further research.

One limitation of the study is related to its exploratory nature. The study developed a model of innovation consisting of four paradigms. While the theoretical and empirical literature, as well as the findings in this study, support the logic of this innovation model and its relevance for agricultural innovation policy, more research is needed to link the innovation model more firmly to the theory of innovation paradigms and networks. An historical analysis of the "life cycle" of different agricultural innovation paradigms and their implications for path-dependent innovation trajectories in the future would be an important further object of study. This should be undertaken at theoretical and empirical level – the former to understand more fundamentally how innovations develop at the interface of different paradigms, and the latter to understand better how different countries are positioned vis-à-vis different paradigms and the implications of their relative positions for innovation policy.

A second limitation of the study (also as a result of its exploratory nature) is the fact that its empirical part has been restricted to a study of four countries. Analysis of a wider range of countries, especially from other continents, would allow validation of the findings of this study. Groups of countries may then be identified with similar positions on the different technology trajectories of each of the four paradigms. This will strengthen the basis for policy advice.

Data limitations for an in-depth analysis of innovation as undertaken in this study are a third issue. They are especially severe for developing countries, and more so if analysis is undertaken at the disaggregated level of individual innovation paradigms. More robust indicators of innovation are needed and their development is an important priority to advance the understanding of innovation processes. It is especially important to understand in much more depth what types of contributions are made by actors in different paradigms to agricultural innovation – this applies especially to non-research types of contributions to innovation (for example the contribution of agri-food chain upgrading to innovation).

The multilevel study approach taken here has both strengths and weaknesses. On the one hand it allows for a more comprehensive analysis. On the other hand, a weakness, well known from the impact assessment literature, is the difficulty of attributing improved agricultural performance at the sector level to investments in agricultural R&D and innovation activities at the level of individual institutes and companies.

Finally, an issue for further research is the pattern observed in this study that there is a weak correlation at the country level between agricultural innovation and sector performance and country scores on a number of indicators (notably the World Bank’s good governance and ease of doing business indicators). The question why good governance, as measured in the indicators, does not translate into higher agricultural innovation performance deserves more thorough analysis.

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Summary

Despite an impressive performance in the past two decades Asian agriculture needs major changes to address the challenges ahead. These include disruptions as a result of rapid globalization, persistent poverty in some countries and regions, exacerbated by rising and more volatile food prices, a declining resource base from which to feed a growing population, increasing environmental problems as a result of resource degradation and climate change, the changing nature of agriculture itself, which is shifting from low value food crops to higher value commodities such as fruits and vegetables, and the emergence of new actors on the scene such as international private sector seed and biotechnology companies.

This study is concerned with the performance of Asian agriculture and how it can become more innovative. It addresses three research questions:

1. What different agricultural innovation models or paradigms have emerged, and how have these paradigms developed from the interaction of driving forces and innovation actors?
2. How do the different drivers, innovation actors, processes and paradigms perform in Asia?
3. How can agricultural innovation organizations interact more effectively in networks, given the constraints imposed by different paradigms, and what policy measures can be taken to promote agricultural innovation?

Part I of the study addresses question 1 at a theoretical and conceptual level. Question 2 is addressed at an empirical level in part II, while question 3 is addressed in part III and presents a synthesis of findings and conclusions. Three innovation drivers are distinguished: internationalization, technical change, and institutional change. Internationalization, analyzed in chapter 2, affects agricultural innovation both directly as well as indirectly through its effects on new technologies and institutions. Whether and how developing countries benefit from the openness that globalization brings depends to a large extent on the quality of domestic institutions and organizations.

Technical innovations, discussed in chapter 3, can have their origins in many different sources. Private companies, universities, public (agricultural) research organizations, and individual farmers develop and disseminate new products, practices and processes. There is a long-standing debate whether innovation is largely driven by new developments in science and technology or by markets dynamics – with both sides supported by empirical evidence. The consensus that has emerged is that innovation is an interactive process which needs to involve different types of actors, institutions (including markets), and technologies.

Institutional change (chapter 4) is also increasingly influenced by changes at the global level. New institutions governing world trade, a global strengthening of intellectual property rights and emerging global standards for food quality and safety are becoming key drivers of agricultural innovation. These new institutional arrangements are not necessarily beneficial for developing countries. National level institutional environments in agricultural innovation

in Asia are determined by rigid, hierarchical structures and processes, with little flexibility to adapt to changing circumstances.

Chapter 5 analyzes the roles of innovation actors. Individuals and organizations make innovation happen and a variety of actors are involved in the agricultural innovation process – both from the public and the private sector. Networks of innovation actors provide opportunities for cooperation not available in markets or in hierarchical organizations. Networks come in many different types and configurations and range from very informal arrangements to networks (e.g. supply chains) that are tightly integrated and based on contractual arrangements. Actors and networks, institutions and technologies can be seen as the building blocks of innovation systems. The idea that technologies and institutions co-evolve as they are developed, adapted, disseminated to and adopted by users, is a basic notion of the innovation systems approach.

Chapter 6 argues that four main techno-institutional paradigms can be distinguished in agricultural innovation in Asia. They result from the interaction of two types of actors (public and private) and two different core drivers (technical and institutional change) and are based on four different revolutions. The green revolution was driven mainly by technological breakthroughs and promoted by public actors. The sustainability paradigm was based largely on institutional changes, and public and civil society actors. The biotechnology paradigm, based on the gene revolution, is a science-driven model dominated by private sector companies. Finally, the supermarket revolution that forms the basis for the agrifood chain paradigm is driven by the private sector and relies mainly on institutional innovation. Part I of the study concludes that agricultural innovation is not only an interactive process, involving a variety of public and private actors. More fundamentally, agricultural innovation encompasses a number of entirely different – often rival – techno-institutional paradigms.

Part II of the study applies the analytical framework developed in part I and analyzes agricultural innovation processes in Asia at a number of levels: starting with macro level agricultural sector and innovation system performance and proceeding to the performance of drivers, paradigms, networks and innovation actors. Specifically, the study analyzes different performance types for four countries (Indonesia, Pakistan, Sri Lanka and Vietnam). Part II starts with a brief introduction (chapter 7) on methodological issues: cases, data, indicators and levels of analysis.

Chapter 8 starts at the most aggregate level of agricultural sector performance in Indonesia, Pakistan, Sri Lanka and Vietnam. The performance analysis is complemented by an assessment of the innovation systems of the four countries, based on published data.

Chapter 9 analyzes performance of the three drivers of innovation: internationalization, technical change and institutional change and assesses how the four different countries have responded to internationalization, invested in R&D and adopted models of institutional change conducive to agricultural innovation.

Chapters 10 and 11 study the types of actors involved in agricultural innovation: public and private. In chapter 10 specific attention is given to the performance of agricultural R&D

organizations, based on information collected at a number of research organizations. The analysis of private sector performance is based on interviews at a number of companies and on secondary data. Special attention is given to the interorganizational linkages necessary for the generation and dissemination of innovations.

A synthesis of findings on the roles of different types of actors is and how they participate in different types of networks is presented in chapter 12 which reviews the presence of agricultural innovation networks in the four countries analyzed.

Chapter 13 presents the conclusions of the study, its value added, its limitations and issues for further research.

Samenvatting

Ondanks indrukwekkende groeicijfers in de afgelopen twee decennia zijn belangrijke veranderingen nodig in de Aziatische landbouw om het hoofd te kunnen bieden aan de grote uitdagingen van de toekomst. Daarbij gaat het om ontwikkelingen als gevolg van snelle globalisering, hardnekkige armoede in bepaalde landen en regio's, die wordt verergerd door de stijging van de voedselprijzen; het feit dat een steeds grotere bevolking gevoed moet worden met steeds minder hulpbronnen (m.n. landbouwgrond en water); toenemende milieuproblemen als gevolg van erosie en klimaatverandering; de veranderende aard van de landbouw, waar een verschuiving zichtbaar is van laagwaardige producten, zoals granen, naar hoogwaardige producten zoals groente en fruit; verschuivingen in het voedingspatroon waarbij mensen meer dierlijke eiwitten gaan consumeren; en het verschijnen nieuwe spelers op het toneel, waarbij het vooral gaat om multinationale zaadveredeling- en biotechnologiebedrijven.

De uitdaging is om in de toekomst meer te produceren met minder hulpbronnen. Dat kan alleen als er slimmer geproduceerd wordt. Deze studie heeft als onderwerp de prestaties van de Aziatische landbouw en in het bijzonder hoe deze innovatiever kan worden. Daarbij komen drie onderzoeksvragen aan de orde:

1. Welke landbouwinnovatie modellen of paradigma's kunnen worden onderscheiden, en hoe zijn deze ontstaan uit de interactie van drijvende krachten en actoren?
2. Wat kan geconcludeerd worden over gedrag en prestaties van deze drijvende krachten, spelers, en paradigma's in verschillende landen in Azië?
3. Hoe kunnen publieke en private innovatie spelers effectiever samenwerken, met inachtneming van mogelijkheden en beperking van de innovatieparadigma's en welke beleidsmaatregelen kunnen worden genomen om landbouwinnovatie te stimuleren?

Deel I van de studie (onderzoeksvraag 1) behandelt deze vragen op theoretisch en conceptueel niveau. Vraag 2 (Deel II) vormt een empirische analyse van innovatieprocessen en achterliggende drijvende krachten en actoren. In deel III worden de resultaten samengebracht in een analyse van netwerken en netwerkrelaties. Daarna worden conclusies getrokken en aanbevelingen gedaan.

Na de introductie (hoofdstuk 1) gaat hoofdstuk 2 in op de belangrijkste drijvende krachten die landbouwinnovatie sturen: globalisering, technologische verandering en institutionele verandering. Internationalisering en globalisering zijn processen die landbouwinnovatie zowel rechtstreeks beïnvloeden, als op indirecte wijze via technologische en institutionele verandering. Globalisering betekent meer openheid, maar of ontwikkelingslanden daar baat bij hebben, blijkt vooral af te hangen van de kwaliteit van de lokale instituties (wetten, regels en praktijken, en de organisaties die deze handhaven).

Technologische innovatie (hoofdstuk 3), kan op veel verschillende plekken ontstaan. Boeren, bedrijven, onderzoeksinstituten, en universiteiten ontwikkelen, veranderen en verspreiden voortdurend bestaande producten en processen. Een belangrijke discussie is of daarbij de vraag vanuit de markt, dan wel het aanbod vanuit technologie en wetenschap doorslaggevend is. Voor beide stellingen is empirisch bewijs en de conclusie moet dan ook zijn dat innovatie een interactief proces is, waarbij vraag en aanbod, technologie en markt, onderzoekers, en bedrijven een rol kunnen en moeten spelen.

Institutionele veranderingsprocessen (hoofdstuk 4) worden steeds meer beïnvloed door internationale ontwikkelingen. Instellingen zoals de Wereldhandelsorganisatie (WTO) bepalen in steeds sterkere mate de beleidsruimte die m.n. ontwikkelingslanden hebben. Daarbij gaat het onder meer om sterkere bescherming van intellectuele eigendom, en nieuwe standaarden en regels voor voedselkwaliteit en -veiligheid. Ontwikkelingslanden hebben niet noodzakelijkerwijze baat bij deze nieuwe instellingen en de wet- en regelgeving die ervan uitgaat. Op nationaal niveau worden instituties in ontwikkelingslanden vaak gekenmerkt door een grote mate van starheid en zeer beperkte mogelijkheden tot aanpassing aan veranderende situaties.

Hoofdstuk 5 analyseert de rol van verschillende actoren (individuen en organisaties) in innovatieprocessen. Publieke en private organisaties spelen daarbij een rol en ontmoeten elkaar in innovatienetwerken. Netwerken vormen naast markten en hiërarchische organisaties een derde sturings- of ‘governance’ model en bieden mogelijkheden voor innovatie die markten of individuele organisaties ontberen. In de praktijk kan een aantal verschillende typen netwerken onderscheiden worden: van losse, informele samenwerkingsverbanden tot strak geregisseerde waardeketens (‘supply chains’). Op een ander niveau van analyse vormen organisaties, netwerken, instituties en technologieën de bouwstenen van innovatiesystemen. Een kernpunt in de analyse van (landbouw) innovatiesystemen is dat technologieën en instituties gezamenlijk evolueren (co-evolutie) en gezamenlijk de processen vormen waarin innovaties worden ontwikkeld, aangepast, verspreid en toegepast door gebruikers.

In hoofdstuk 6 worden op basis van verschillende typen organisaties en het relatieve belang van technologische en institutionele innovatie vier verschillende landbouw innovatieparadigma’s onderscheiden. Deze ontstaan uit de interactie van publieke en private organisaties en technologische en institutionele innovaties. Aan de basis van ieder van de paradigma’s staat een revolutie. De **groene revolutie** was gebaseerd op technologische vernieuwing (nieuwe variëteiten) en publieke onderzoeksorganisaties. De **duurzaamheidsrevolutie** was een reactie op de groene revolutie; ze werd gedreven door publieke belangen maar richtte zich op institutionele- en managementvernieuwingen op bedrijfsniveau (andere vormen van plantenteelt, bodem- en gewasbescherming). De genetische of **biotechnologie revolutie** wordt gestuurd door grote particuliere ondernemingen en is in hoge mate gedreven door de nieuwe technologie van genetische modificatie. Tenslotte heeft de **supermarkt revolutie** in ontwikkelingslanden sinds het begin van de 21ste eeuw geleid tot een sterke groei van het belang van voedselketens. Hier gaat het vooral om institutionele innovatie – nieuwe vormen van contractlandbouw, logistiek en distributie, en kwaliteitsstandaarden.

Deel II van de studie past het theoretische raamwerk ontwikkeld in het eerste deel toe en analyseert landbouwinnovatieprocessen in Azië in vier landen: Indonesië, Pakistan, Sri Lanka en Vietnam. De analyse wordt uitgevoerd op verschillende niveaus, te beginnen met het macroniveau, waar in kaart wordt gebracht hoe de landbouwsector en het (landbouw) innovatie systeem in de verschillende landen presteren. Vervolgens wordt geanalyseerd hoe de drijvende krachten, organisaties en innovatienetwerken zich in de verschillende landen manifesteren.

Hoofdstuk 8 presenteert de situatie op macroniveau met een analyse van ontwikkelingen in de landbouwsector in de vier landen, waarbij vooral wordt gekeken naar groei en productiviteitsontwikkeling. Daarbij zijn grote verschillen te zien tussen snelle groeiers in Zuidoost Azië en veel langzamere ontwikkeling in Pakistan en Sri Lanka. Dit beeld wordt bevestigd in een analyse van capaciteit en prestaties van innovatiesystemen.

Hoofdstuk 9 vervolgt de landenanalyse met een discussie van resultaten en prestaties van de verschillende landen ten aanzien van drijvende krachten internationalisering, technologische en institutionele innovatie. Daarbij wordt in kaart gebracht hoe landen de globaliseringsuitdaging beantwoorden, hoe ze in onderzoek en technologieontwikkeling hebben geïnvesteerd, en in hoeverre men instituties heeft ontwikkeld of overgenomen die kunnen bijdragen aan innovatie.

Hoofdstukken 10 en 11 analyseren in detail de rollen van respectievelijk publieke en private innovatie actoren. In hoofdstuk 10 wordt speciale aandacht gegeven aan de rol en het functioneren van publiek gefinancierde onderzoeksinstellingen in de vier landen op basis van veldwerk bij deze instellingen. De analyse van de rol van private ondernemingen in onderzoek en innovatie in hoofdstuk 11 is gebaseerd op veldwerk en secundaire data.

Deel III rondt de studie af. Hoofdstuk 12 presenteert een synthese van de onderzoeksresultaten over de rollen van en de relaties tussen verschillende typen actoren in innovatienetwerken, de relaties tussen verschillende typen innovatienetwerken en innovatieparadigma’s, en het relatieve belang ervan in de vier landen.

Hoofdstuk 13 presenteert de conclusies van de studie en constateert dat er grote verschillen zijn tussen de landen waar het gaat om het belang van verschillende paradigma’s, netwerken en actoren. Deze analyse vormt de basis voor beleidsaanbevelingen. Tenslotte worden beperkingen van de studie en vragen voor vervolgonderzoek gepresenteerd.

Biography

Govert Gijsbers started working on agricultural innovation issues in 1976 when, as part of a research project at the Free University in Amsterdam he did field work in an *ejido* in central Mexico on the adoption of agricultural innovations. In 1978 he graduated with a Masters degree in regional development.

From 1979 to 1989 he worked for the United Nations in Sierra Leone, Honduras and Indonesia. In Sierra Leone he focused on regional development planning in a project based at the Ministry of Development and Economic Planning. In Honduras he participated in an integrated rural development project in the Aguán region, working with agricultural cooperatives and focusing on agro-industrial development projects. From 1985 - 1989 he was based in Bogor, Indonesia, where he worked for the UN’s Economic and Social Commission for Asia and the Pacific (ESCAP) at a research center that focused on agricultural diversification strategies through research on farming systems and secondary food crops.

In 1989 he returned to the Netherlands to take up a position at the International Service for National Agricultural Research (ISNAR), an organization committed to improving the performance of national agricultural research organizations in developing countries. He left ISNAR in 1992 to join the Netherlands Ministry of Foreign Affairs to start up a biotechnology for development program in Andhra Pradesh, India. Returning to ISNAR in 1996, he focused on agricultural research planning, on institutional development and on performance improvements in agricultural research organizations. From 2000-2003 he led a project on performance-based management, covering four countries: Indonesia, Pakistan, Sri Lanka and Vietnam. The assessments of organizational performance, staff performance, governance issues and linkages, undertaken in the context of that project form the basis for the present PhD project.

Following the demise of ISNAR in the Netherlands, he joined TNO, the applied research organization in the Netherlands, working with the Innovation Policy group. He is focusing on monitoring and impact assessment of innovation policies, the dynamics of research systems and knowledge infrastructures. At TNO he has led or participated in a number of multi-country EU studies and in projects in the Netherlands, Russia, and South Korea.

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The study finds that four different techno-institutional paradigms can be distinguished basedonfourrevolutionsinAsianagriculture:thegreenrevolution,thesustainabilityrevolution, the biotechnology revolution and the supermarket revolution. These paradigms are based on four fundamentally different technologies, involve different actors and innovation networks and show different patterns of performance across Asia. To be effective agricultural research and innovation policies need to reflect the specific opportunities and constraints of the four techno-institutional paradigms.

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