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Innovation Systems Governance in Bolivia

Lessons for Agricultural Innovation Policies

Frank Hartwich, International Food Policy Research Institute
Anastasia Alexaki, Independent Consultant
and
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International Service for National Agricultural Research Division

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ABSTRACT

Traditional approaches to innovation systems policymaking and governance often focus exclusively on the central provision of services, regulations, fiscal measures, and subsidies. This study, however, considers that innovation systems policymaking and governance also has to do with the structures and procedures decision makers set up to provide incentives for innovating agents and the interaction and collaboration among them, thus enabling innovation. Based on the concepts of agent-centered institutionalism and innovation systems, governance can be understood to refer to integrating multiple government and non-government actors in different actor constellations depending on roles, mandates, and strategic visions. Any effort to govern the system composed of those agents needs to take into account the limitations that any policymaking body has in dictating how agents behave and interact. In consequence governance in innovation systems has less to do with executing research and administering extension services and more to do with guiding diverse actors involved in complex innovation processes through the rules and incentives that foster the creation, application, and diffusion of knowledge and technologies.

The report presents results from a study that analyzed to what extent the Bolivian Agricultural Technology System (SIBTA), as part of the country's agricultural innovation system, has complied with a set of governance principles—including participation of stakeholders (especially small farmers) in decision making, transparency and openness, responsiveness and accountability, consensus orientation and coherence, and strategic vision—and compares those principles with benchmarks of innovation systems governance in five other developing countries. Data in Bolivia were collected by means of an expert consultation and interviews with a wide range of key actors and stakeholders from various organizations involved in agricultural innovation in the system. The empirical findings of the study suggest the following:

- A research and technology transfer program such as SIBTA constitutes only part of an innovation system and there are other important complementary functions with which the government has to comply to foster innovation. Rather than aiming to carry out research and extension, governments should focus on overall planning on the macro level and bringing the above functions together so they reach the innovating agents. To do this they need to involve themselves in planning and policy analysis, the setting of consultation platforms, supporting the building of innovation networks, and setting up specific funding mechanisms.
- Setting up decentralized semiautonomous agencies that administer funds and design innovation projects does not automatically lead to sufficient participation of local producer organizations and technology providers. More participation requires special rules and incentives to collaborate and the special efforts of all involved, and eventually further decentralization on the regional level.
- Weak leadership and limited commitment, rather than a decentralized structure or the delegation of too much power, have prevented governments from taking a more active role in governing their innovation systems. Decentralization, however, should not stand in the way of a national strategic vision, and mechanisms need to be put in place to discuss and harmonize national- and local-level priorities.
- Simply being responsive to the demands of farmers does not necessarily imply that one is generating the best technical solutions. Generating adequate innovations requires the participation of many: leading and other producers, knowledge and technology providers, buyers, input sellers, funding agencies, advisory services, and others. It also requires analysis and identification of technological and market opportunities. Policymakers should foster in-depth analysis of farmers' demands on the local level through decentralized organizations, which simultaneously help to orient these demands to where technological and market opportunities lie. This requires improved analytical and planning capacities as well as intensive communication with the farmers and agents who benefit from new and promising technologies.

Key words: Agricultural Innovation System, Governance, Innovation Policy, Bolivia

ABBREVIATIONS AND ACRONYMS

CIAL	Local agriculture research committee (comité de investigación agrícola local)
CIAT	Tropical Agriculture Research Center, Bolivia (Centro Internacional de Agrícola Tropical)
CIFP	Fitogenetic Research Center of Pairumani (Centro de Investigaciones Fitoecogenéticas de Pairumani)
DANIDA	Danish International Development Agency
DFID	Department for International Development
FDTAs	Agricultural and forestry technological development foundations (fundación para el desarrollo tecnológico agropecuario y forestal, being part of SIBTA 4 FDTAs currently exist in Bolivia: FDTA Altiplano, FDTA Chaco, FDTA Trópico Húmedo y FDTA Valles)
FPTA	Fund to Promote Agricultural Technology, Uruguay
GDP	Gross domestic product
GTZ	German Agency for Technical Cooperation (Gesellschaft fuer Technische Zusammenarbeit)
IADB	Inter-American Development Bank
IBTA	Former Bolivian Institute for Agricultural Technology (Ex Instituto Boliviano de Tecnología Agropecuaria)
IDR	Institute of Rural Development (Instituto de Desarrollo Rural), Nicaragua
IFPRI	International Food Policy Research Institute (Instituto Internacional de Investigación sobre Políticas Alimentarías)
LAC	Latin America and Caribbean
MACA	Former Ministry of Farmers' Affaires and Agriculture, now Ministry of Rural and Agricultural Development and Environment (Ex Ministerio de Asuntos Campesinos y Agropecuarios ahora Ministerio de Desarrollo Rural y Agropecuario y Medio Ambiente [MDRAyMA])
MDRAyMA	Ministry of Rural and Agricultural Development and Environment (Ministerio de Desarrollo Rural y Agropecuario y Medio Ambiente)
MIFIC	Ministry of Finance, Industry, and Commerce (Ministerio de Finanzas, Industria y Comercio), Nicaragua
NARI	National agricultural research institute (INIA in Spanish)
NARS	National agricultural research system
OECD	Organization for Economic Co-operation and Development
PIEN	National Strategic Innovation Project (Proyecto de Innovación Estratégica Nacional)
PITA	Applied technological innovation project (proyecto de innovación tecnológica aplicada, funding mechanism for applied research and technical assistance within the frame of SIBTA)
PROINPA	Foundation for the Promotion and Research of Andean Products, Bolivia (Fundación Promoción e Investigación de Productos Andinos)
SAI	Inter-American Agricultural Service (Servicio Agrícola Interamericano)
SDC	Swiss Agency for Development and Cooperation
SIBTA	Bolivian System of Agricultural Technology (Sistema Boliviano de Tecnología Agropecuaria)
SINAGREAA	National System for Management, Conservation, Utilization, and Evaluation of Genetic Resources for Agriculture and Food (Sistema Nacional de Manejo, Conservación, Utilización y Evaluación de los Recursos Genéticos para la Agricultura y Alimentación)
UCPSA	Coordination Unit for the Agricultural Services Program (Unidad de Coordinación para el Programa de Servicios Agropecuarios)
UTS	Technology and Health Unit (Unidad de Tecnología y Sanidad), former Department in MACA
USAID	United States Agency for International Development

1. INTRODUCTION

Today governments in many developing countries face a paradox. On the one hand, they are expected to take an active role in fostering development and solving the major problems confronting their impoverished societies. On the other hand, people increasingly distrust governments and their institutions or are simply not interested in them any more because of previous negative experiences. This paradox can be noted also in the field of agricultural development policy. Policymakers experience increasing pressure from poor rural communities, larger producers, agro industry companies, and consumers challenging existing priorities and state institutions and programs. Meanwhile policymakers also note increasing frustration among those same agents, who wonder whether governments really can make a difference. The main reason for this is that the solutions offered by government policies and institutions have often not satisfied the intended beneficiaries; the little progress, for example, made in many countries in lifting smallholders out of poverty and the sluggish adoption rates of propagated new knowledge and technology among poor farmers provide evidence for this.

Countries such as Bolivia have experienced many difficulties in agricultural development due, in part, to a depleted natural resource base and deficiencies in the areas of financing, access to markets, information and knowledge exchange, orientation toward needs, and cooperation between the public and the private/productive sectors, innovative capabilities; but the difficulties also stem from reasons that have to do with a lack of knowledge among decision makers in the government about how to steer and foster innovation processes. In particular, Bolivia, in the last five years, has undergone a learning process after establishing a new decentralized agricultural research and technology transfer system, the Bolivian System of Agricultural Technology (SIBTA). SIBTA put the main functions of identifying demands for research and development and channeling funds to knowledge and technology providers in the hands of four regional foundations, and the functions of setting global priorities and monitoring and evaluation in the hands of central government units in the Ministry of Agriculture. The way the Bolivian government has governed SIBTA has been a subject of continuous debate among those working in and affected by the system as well as among government officials and donors, throughout SIBTA's operation and particularly in the last year of political change. Some advocate for the government to take a stronger role, whereas others argue that the state should stay away from carrying out research and extension as there are other independent agents who can provide these services in a more efficient way.

The governance of an innovation system can be understood as the structures and procedures policymakers set forth to foster innovation and provide incentives to innovating agents and the interaction among them. The governance of SIBTA, as part of the Bolivian agricultural innovation system, has been characterized by decentralized funding, outsourcing of research and technology transfer activities to small

local knowledge providers and consultancy firms as well as independent research organizations, and monitoring and evaluation through government and donor institutions. The government, through the Technology and Health Unit (UTS) under the Directorate of Productive Development in the Ministry of Agriculture (today the Ministry of Rural and Agricultural Development and Environment), provides for strategic orientation, national-level priorities, and coordination of activities among the various actors as well as the organization of evaluations and stakeholder consultations and contacts with the international research community. The Coordination Unit for the Agricultural Services Program (UCPSA), also a government agency but established outside the ministry because of austerity rules of the Inter-American Development Bank (IADB) grant, administers funds and monitors implementation of projects. These government agencies have been at times antagonistic in their operations, and the setting of priorities and monitoring of results may not always have been optimal.

In this report we identify successes and failures in policymaking for agricultural research and innovation in Bolivia and discuss options for good governance in agricultural innovation systems in general. We try to answer the question of how an innovation system in a developing country composed of various public and private agents can be best governed so that it fosters the generation and diffusion of agricultural innovations. This may be important information in the current sociopolitical context in Bolivia, where the challenge is to find out how the Bolivian government can best approach and adjust SIBTA and other policies and programs that foster agricultural innovation. It may also be important information for many developing-country governments that are trying to improve agricultural innovation performance to meet pressing needs in food supply, rural development, and poverty alleviation. In this regard some important issues are, for example, as follows: What can governments do to help farmers and other entities in the productive sector to innovate? And how can the exchange of knowledge and technology among the various agents be fostered, responding to development priorities and demands, especially from the rural poor?

To address these questions we study the existing literature on the governance of innovation systems and review experiences in Bolivia and abroad that relate to innovation systems governance in general, and to agricultural innovation and development in particular. We then develop a framework for the study of innovation systems governance that allows us to identify principles of good governance in innovation systems. The framework is then applied to an analysis of governance in SIBTA, drawing from an expert consultation and a number of interviews with key actors in the system. Based on this we develop matrices of relational data that depict the intensity and quality of the relationships the different agents maintain to perform governance functions.

The paper is structured as follows. The next section presents an overview of the literature on innovation systems governance, reflecting on the main debates and defining main principles in innovation

systems governance and illustrating them by means of five benchmarks in countries around the world. The third section outlines the methods used in the analysis. Section 4 presents a descriptive analysis of the study case, the Bolivian System of Agricultural Technology. Section 5 provides results from the analysis of how SIBTA has complied with certain government principles. In the sixth section governance options for the Bolivian national agricultural innovation system are discussed. The last section provides some general conclusions with implications for Bolivia and other developing countries that aim at improving innovation systems governance in the field of agriculture.

2. THEORETICAL BACKGROUND: INNOVATION AND GOVERNANCE

As the complex dynamics of innovation processes are only slowly becoming understood, policymakers often still struggle to define the criteria by which to set innovation policies and to apply the appropriate rules to govern their innovation system. The governance of innovation systems is still an unexplored territory in developing-country development policy. This section discusses approaches to innovation systems governance from the perspectives of innovation systems theories and governance theories.

2.1 Innovation Systems and Policies

Innovation can be understood as a creative and interactive process of making improvements by successfully introducing something new into social and economic practices. In the innovation process various forms of knowledge and technology are used to generate and diffuse new and improved knowledge and technology in reaction to technological demands, market opportunities, and overall social needs. The innovating agents, that is, producers and other actors that apply the innovation in their economic practices, acquire knowledge and technology in interactive processes of competence building that go beyond "demand pull" and "technology push" dynamics (Cimoli and Primi 2003) and take place through learning by doing, learning by using, and learning by interacting (Lundvall et al. 2002).

Innovation policies can be understood as public actions that influence innovation processes, that is, the development and diffusion of product and process innovations (Chaminade and Edquist 2007). Central policy questions are to what extent the government should involve itself in the generation and promotion of innovation, where it should provide subsidy and incentives, and where it should leave activities to the private sector. Traditionally innovation policies have concentrated on science and technology, research, or extension, and simple public and private good considerations, and have neglected the facts that innovation involves complex processes and many diverse agents in the public and private sectors and that the product of innovation is a good that agents can neither access freely (due to the cost of learning and anticipation) nor completely restrict access to through intellectual property rights legislation (at least in developing countries).

From the 1950s to the 1980s innovation policies in developing countries often followed a linear model by which the government and development agencies supported separate lines of intervention such as research institutes, training and visit programs, credit schemes, and agricultural subsidies. Knowledge was expected to be generated by scientists, handed down to researchers for adaptive research and extensionists for diffusion, and then finally adopted by farmers. Cimoli and Primi (2004) in the Latin American context refer to this as the period of policies of public supply characterized by linear, top-down knowledge diffusion, selective and centralized research and development efforts in public institutions and

enterprises, and predominance of the public sector. From the perspective of policy, this often meant that priorities were set by public planners, allowing for only the marginal participation of the many agents involved in the innovation process, especially in the private sector.

Beginning in the 1980s, in line with structural adjustment and liberalization policies, economists argued that policies should be attached to market equilibrium criteria. Neoclassic approaches assumed that there are market failures associated with innovation processes: knowledge (usually assumed to emanate from research) is uncertain, inappropriate (firms can't appropriate the benefits that are derived from inventions), and indivisible, leading to underinvestment in research activities by private actors and hence providing an argument for governments to invest in such activities. For science, technology, and innovation policy this meant that the state would involve itself in the promotion of innovation only when it was related to the generation of a public good. Further state policies limited the state's involvement to interventions that ensured the functioning of (technology) markets and the setting of legal frameworks to protect property rights. It was assumed that the dynamics of markets and especially firms through their demand would sufficiently promote the generation and diffusion of knowledge and technology. The main characteristics of this period were mechanisms that supported (subsidized) the articulation of demands of the productive sector and lower levels of spending on science and technology (Cimoli and Primi 2004).

Recently decision makers in innovation policy in the public and private sectors have experimented with approaches to innovation policymaking rooted in the innovation systems concept as established by Freeman (1987), Dosi et al. (1988), Lundvall (1992), Nelson (1993), and Edquist (1997). These approaches to innovation policy see innovation as an outcome of interactions between the productive and the science and technology sectors supported by government programs (OECD 1999). They suggest that the set of interrelated organizations,[1] institutions,[2] and practices that constitute, perform, and participate in innovation processes is what constitutes an innovation system. The main elements of such a system are the different agents that contribute to the generation and diffusion of innovations, the communication and interaction among those agents, and the policies and institutions that enable the agents to act and interact. From the innovation systems perspective, innovation is seen as a nonlinear process that involves not only research but also a complex set of many related activities, including technology transfer, capacity strengthening, learning, design, finance, and others (Lundvall 1992).

Understanding innovation as a complex interactive process has important implications for the design and implementation of innovation policies. It affects the focus of the policy, the instruments, and

1 Organizations are seen here as consciously created formal structures with an explicit purpose (Edquist and Johnson 1997.

2 Institutions are seen here as sets of common habits, routines, established practices, rules, or laws that regulate the relations and interactions between individuals, groups, and organizations (Edquist and Johnson 1997).

the rationale for public policy, among other issues (Chaminade and Edquist 2006). It shifts the focus toward the combination of innovation and learning (Lundvall 2006). Whereas standard economics predominantly analyzes institutional setups that lead to optimal allocation of existing resources, the innovation systems perspective focuses on how different institutional setups affect the creation of new resources and capacities. The systemic approach does not imply that these innovation systems are or can be consciously designed or planned. On the contrary, just as innovation processes are evolutionary, innovation systems evolve over time in a largely unplanned manner. Centralized control over innovation systems is impossible, and innovation policy can influence their spontaneous development only to a limited extent.

Another implication of the innovation systems approach is that knowledge is not considered a public good. Accessing knowledge, either being knowledge that the individual holds explicitly and consciously in mental focus and can be codified and communicated to others or tacit knowledge that people carry in their minds and they only acquire through learning by doing, depends on the strategic positioning of agents in a network of communication and information exchange. Agents in dominant positions in these networks employ the capacities of decodifying and translating knowledge, which allows them to learn and accumulate it for their own use. Knowledge becomes a club good; nonrival in its consumption, but its utilization is exclusive to those who can decodify it. The capacity of decodification is acquired through costly processes of learning. This implies that policies should focus on both fostering the generation and diffusion of knowledge as well as strengthening the absorptive capabilities and decodification skills of potential users and the articulation of their demands. Innovation policies need to find an optimal division between the two: subsidizing public research and extension and subsidizing articulation of the demand and learning and uptake skills of potential users of innovation.

It is also necessary that innovation policies support collaboration and the sharing of scarce resources for innovation. Competition between innovation providers may be beneficial only to the extent that critical masses of innovation capacity are met. These policies can be complemented by mechanisms that prioritize specific subsectors or territories in order to not divert scarce innovation resources across too many activities.

Testifying to the recent prominence of the innovation systems approach are the increase in public funding for science, technology, and innovation in many countries, the formulation of new innovation policy frameworks and plans, and the setting up of high-level policy bodies to oversee innovation development policies that are currently being implemented in many developed as well as developing countries. For example, Finland in the 1990s created the Science and Technology Council, which is headed by the prime minister and integrates the areas of education, industry and trade, finance, and four other ministries and 10 member organizations from the field of science and technology. Denmark in 2002

set up a Super ministry of Science, Technology, and Innovation, which handles a major part of the country's development budget and incentives for private-sector development.

There are qualitative and quantitative differences in the roles innovation systems play in developed and developing countries (Melo 2001b). In developed countries the focus is usually on maintaining or improving already established levels of knowledge, technology, and competitiveness, whereas in developing countries the issue is to bridge gaps and catch up. Edquist (2001) introduced the notion of a *system of innovation for development,* which he considers to differ from an innovation system in a developed economy in four main areas:

1. Product innovations may be more important than process innovations because of the effect on the existing deficiencies in the product structure of developing countries
2. Incremental innovations may be more important and attainable than radical ones.
3. Absorptions (diffusions) of innovations may be more important than development of innovations that are new to the world.
4. Innovations in low- and medium-technology sectors may be more attainable than ones in high-technology sectors.

In cases where producers are not at the technological frontier or when the research and development capacities are limited, producers should seek rather to rely on imported information and technology. At times this gives a certain "latecomer advantage" to developing countries because copying knowledge and technology is less costly then developing it. Considering a historical context where developed countries are technological leaders and developing economies are followers, the absorptive capacity of the latter is very important in the process of innovation. Developing countries can obtain technology by contracting or setting agreements with firms, universities, labs, and so forth in developed countries; then in developing economies the focus shifts from innovation to a learning process. This also relates to "strategic trade" arguments, which suggest that benefits from local research spill over to other countries, especially to consumers but also to producers and marketers, and results from research abroad spill into the local economy. Hence it is beneficial for small, open economies to not invest entirely in costly science and research but to buy and copy technology from abroad and adapt it to local conditions.

In fact, the innovation systems approach to science and technology and innovation policymaking is recently being given increased consideration in developing countries (Cimoli 1998, Johnson and Segura-Bonilla 2001, Juma et al. 2001, Arocena and Sutz 2003). In Latin America, for example, views of innovation traditionally have been influenced by the debate about industrial policy. Melo (2001a) documents two phases in the reforms that have followed the import substitution era. In the first phase—from roughly the late 1980s to the mid-1990s—countries in the Latin America and Caribbean (LAC) region sought to implement basic structural reforms related to export trade, privatization, domestic market

liberalization, and regulation. At the same time, they curtailed explicit (sector-targeted) industrial policies. The logic was that government intervention in liberal market economies is necessarily very modest and that industrial policy is generally prone to distortion and corruption. Yet Melo finds that by the mid-1990s many LAC states had already begun to abandon that strictly hands-off philosophy in favor of explicit public-sector strategies aimed at enhancing the competitiveness of particular sectors, value chains, and firms. This second phase, which is ongoing and still without definitive results, reflects a view of government intervention that is more nuanced, particularly as it pertains to technology and the complexity of innovation processes.

Meanwhile, in the last few years, not in the least in response to the initiative of various Latin American counties and the OECD to develop the Bogotá Manual for the standardization of indicators of technological innovation in LAC countries (RICYT/OAS/CYTED 2001), innovation policymaking has embraced ideas of the innovation systems approach. For example, Costa Rica is currently negotiating the formulation of a new law of innovation; Colombia is undergoing intensive consultations on how to put the innovation systems concept, which it has already embraced through law, into practice; Chile and Mexico have passed new legislation that provides for substantial funding schemes to promote innovation within clusters of private firms; Honduras, Ecuador, Nicaragua, and Peru are trying to strengthen their national science and technology councils; and Uruguay has set up an Innovation Cabinet bringing together its ministries of economy, production, and education and representatives from the science and technology sector.

Other inroads into innovation policymaking can be found in the field of political economy. Such approaches suggest that even if one could design perfect policies (e.g., based on the neoclassic economic equilibrium approach), a real-world government would likely be unable to implement them because of the insufficient capabilities of civil servants, problems with principal-agent relationships and cognitive limitations among policymakers to work toward social returns. Ideally such political constraints should be taken into account when designing innovation policies looking to embrace opportunities of best practice. Newer approaches in the context of complex adaptive systems suggest that strategic planning mechanisms are not efficient because it is difficult, if not impossible, to predict the outcome of policy interventions given the interplay between the individual decisions of a great variety of agents and random elements (Axelrodt and Cohen 1999). These approaches suggest that political decisions have limited influence on the evolution of the system and therefore should follow broad principles rather than detailed control mechanisms. Policies should focus on orientation and providing agents with incentives in order to augment the probability of a positive system outcome. They also need the flexibility to adjust rapidly to unexpected changes. For this policymakers need to have in place powerful monitoring systems and the

analytical capacity to continuously process information about the development of the system and changes within it.

Some scholars of innovation systems have focused particularly on the innovation processes that occur in networks characterized by intensive interaction and learning among a range of agents, including many producers (of which some have more innovative capacities than others) and promoters of innovation such as research institutions, knowledge consultants, development programs, buyers, input providers, funding agents, and many others. Such networks are often local in nature but can extend to the national and international levels. In a developing-country context, where these networks are only about to be created, requiring at times substantial aid from the outside, the appropriate scale is on the local level while ensuring the inflow of external knowledge through a number of knowledge and technology providers.

2.2 Innovation in Developing-Country Agriculture

The nature of rural poverty in many developing countries is changing as a result of new technological, market, and institutional opportunities, improved infrastructure, and at times improved access to services and resources. Today, the rural poor depend less on agriculture and more on nonfarm income than they did 30 years ago. Yet despite the expanding livelihood options for the rural poor, poverty is still prevalent. Several obstacles have prevented smallholder farmers and other vulnerable groups from benefiting from such opportunities. For example, subsistence farmers and rural entrepreneurs have not been able to enhance productivity, maintain the natural resource base, and diversify their livelihood options. In addition, these same groups have often been unable to produce necessary surpluses and levels of quality to enable them to participate in territorial development schemes, value chains, and/or specific markets. Above all else, these groups have failed to take advantage of such opportunities as a result of insufficient access to new and existing knowledge and technology—on how to enhance production, improve livelihoods, market surplus output, and meet quality standards. In other words, smallholder farmers and other groups are challenged by weak abilities to search for and use information, combined with institutional constraints that limit their innovative capabilities and opportunities.

From this the following question emerges: How can we enhance the ability of smallholder farmers and other marginalized groups to access and absorb knowledge and technologies and benefit from the opportunities of using them? Various models and concepts have been developed and used in response to this question, of which some of the most prominent are introduced in the following paragraphs. Only those models and concepts that deal explicitly with innovation are introduced.

National Agricultural Research Systems

The national agricultural research system (NARS) model suggests that all research related to agriculture in a country forms a hierarchical system that is administered through a coordinating body in the government. In theory, a NARS does not include extension and technology transfer agencies but is closely linked to them; the assumption is—following a pipeline model of technology transfer—that researchers will hand down research results to extensionists, who will then diffuse them to farmers. The NARSs have often been dominated by national agricultural research institutes (NARIs; INIAs in Spanish), which have tended to receive the main share of government and donor funding (Trigo and Kaimowitz 1994). However, the introduction of competitive grant schemes and ideas of institutional coordination has opened up the NARSs to participation by other providers of research and development such as universities and other public and private research organizations. The NARIs were supposed to carry out adaptive and strategic research by considering the research results that were handed to them from the international research system. The performance of NARSs has usually been measured in scientific output and through internal rates of return on investment in public research. Some NARSs have experienced difficulties with bureaucratic planning processes and strong dependence on government administration; others soon moved ahead to more flexible forms of fostering agricultural innovation. NARSs have been particularly challenged by failures in production increase, lack of efficiency in generating relevant research results applicable in local contexts, incapacity to deal with issues of local pro-poor development and environmental conservation, lack of participation of farmers and other stakeholders and tendencies to shrink employment of government researchers (e.g. Hall et al. 2005).

Agricultural Extension and Advisory Services

The NARS has usually been complemented by a public agricultural extension program or technical advisory services agency to diffuse the knowledge and technologies developed in the NARS. These usually have been organized via local and regional extension offices. Training and visit programs have been prominent concepts for diffusing knowledge through extension agents; others have included field days, field schools, and farmer-to-farmer communication, among others. Newer concepts of extension challenge the idea of simply transferring knowledge and incorporate more systemic approaches and facilitating roles. The focus has moved away from passing down technical solutions to emphasizing assistance to farmers so that they can organize themselves and act collectively, partner with service providers and rural institutions, and participate in joint learning (Birner et al. 2006).

The AKIS Perspective

The agricultural knowledge and information system (AKIS) perspective is a further development of the agricultural technology system concept (Elliott 1992) through the works of Nagel (1979) and Röling (1986). Röling and Engel (1991) define an AKIS as a set of agricultural organizations and/or persons, and the links and interactions between them, engaged in such processes as the generation, transformation, transmission, storage, retrieval, integration, diffusion, and use of knowledge and information, with the purpose of working synergistically to support decision making, problem solving, and innovation in a given country's agriculture. AKIS actors include farmers; farmers' organizations; cooperatives; specialized services; universities; groups and study clubs; agro-based industries; public- and private-sector research, extension, and training institutions; agricultural press and information services; agricultural policy units; and formal and informal networks of many kinds. The AKIS is concerned with the various actors involved along the knowledge generation chain while taking into account the variety of feedback and dynamics between those actors. According to Engel (1990) the performance of an AKIS has to be measured in terms of the contribution to sustained agricultural adaptation and has to be envisaged as the combined outcome of the policies and actions of many, not necessarily cooperating, actors. The AKIS concept has been lately adopted in the World Bank's approach to extension and is commonly used by practitioners from different development agencies who combine it with participatory research approaches (Chambers 1992). Some common critiques of the AKIS concept include its insufficient focus on concrete technological solutions and its incapacity to deal with agents on a broader sectoral, program, or commodity scale. Although application of the AKIS concept in concrete policymaking has been rather anecdotal, it remains a great achievement to have introduced an explicit farmers' perspective and to have shifted emphasis to the understanding of interaction and knowledge flows on a farm and community level.

Agricultural Value Chain and Cluster Development

Value chains are sectoral arrangements that allow buyers and sellers of a commodity who are separated by time and space to progressively add and accumulate value as products pass from one member of the chain to the next. In agriculture, product or value chains (agrichains) include all actors that trade, produce, or otherwise deal with a certain agricultural commodity, ranging from the agricultural input industry via producers, transporters, processors, and marketers to the final consumer. For developing countries, work on value chains has focused on global governance (Gereffi, Humprey, and Sturgeon 2005), distribution of gains among chain actors (Gereffi 1999), the power of buyers (Humphrey and Schmitz 2000), and the opportunities of agents from developing countries to get involved in value chains and share parts of the value added they generate (Kaplinsky 2000; Pérez et al. 2001; Daviron and Gibbon 2002). Gereffi, Humphrey, and Sturgeon (2005) see innovation as a major opportunity to "upgrade" technologically

underdeveloped producer groups in developing countries. The value chain approach has been prominently applied on the national level by many theorists and government development programs (Kaplinski and Morris 2001), in particular, in Latin American agriculture (Herrera 2000). Countries like Colombia, Ecuador, El Salvador, Peru, and many more have embraced the idea of developing specific agrichains and increasing their competitiveness, and donors have supported this approach (e.g., Humphrey 2005). In many cases these policies relate to a cluster development approach (Altenburg and Meyer-Stamer 1999; Porter 1998), that is, the development of industries in a certain geographical context to profit from economies of scale, buyer and seller networks, and dynamics of joint learning. Many theorists have propagated cluster development strategies based on technologies accessible to all members of the cluster. Other scholars have seen the limits of this approach to pro-poor development—producers often lack the capacity to be included in the cluster—and favor more holistic territorial development approaches (Alburquerque 1997).

Territorial Development

In the search for new ways to overcome poverty, rural territorial development is the subject of increasing debate in Latin America (Moncayo 2001). A main tenet of the approach is that economic development has regional, territorial, local, and community dimensions (Alasia 2003). Rural territorial development can be seen as a process of productive and institutional transformation of a rural region or territory, whose final purpose is to reduce rural poverty. Productive transformation aims at improving production processes, in other words, innovation, in such a way that they better link to opportunities and agents that are able to improve competitiveness in markets and sustainability. The approach also postulates that productive transformation and institutional development should be addressed simultaneously, and that measures aimed toward improved competitiveness, technological innovation, and linkages to markets need to be established—and the best way would be on a contractual basis that allows exchange of knowledge, acquiring of skills, and partnering among various innovative agents (Shejtman and Berdegué 2004). Here the territorial approach overlaps with the concept of local innovation networks, which are aimed at understanding agent relationships that lead to the introduction of new knowledge and technology in social and/or productive processes. However, little empirical evidence has yet been gathered on the efficacy of the approach. Among its main challenges is the need to define lines of action and policies that mobilize the underutilized productive potential of local territorial resources and foster innovation, local complementarities, and social inclusion of the poor.

Innovation Systems

The innovation systems approach goes further than the NARS or the AKIS models, focusing on core and more peripheral agents in the innovation process, the interaction among them, and the rules, policies, and institutions that guide agents and their interactions (see section 2.1). It also shifts the emphasis from research and technology transfer to the innovation process itself. Innovation is the successful introduction of anything new in social and/or economic processes. As such it is the farmer or any other productive agent and not the researcher or extensionist who innovates. Consequently innovations do not always originate from formal research and development, nor are they all exclusively technical. This new perspective puts more emphasis on the roles of farmers, input suppliers, transporters, processors, and markets in the innovation process. Adopting the innovation systems perspective to agricultural and rural development enables us to investigate issues traditional technology transfer theory could not deal with, such as: Why do farmers innovate? What constraints hold them back? What are the roles of input suppliers, associations, neighbors, traders, processors, nongovernmental organizations (NGOs), researchers, extensionists, and whole social networks in technology development and diffusion? To what extent do farmers orient towards existing opportunities for innovation and to what extent do farmers get involved in processes of knowledge adaptation?

The innovation systems approach has been applied to agricultural development in developing countries by Hall (2002), Spielman (2006) and the World Bank (2006). A common feature among those authors is that they emphasize the importance of access to knowledge and technology in the development of small farmers. Authors in the Latin American context have focused on innovation systems in general (Melo 2001a), the pro-poor aspects of innovation systems (Alcorta and Peres 1995), and poverty alleviation in rural areas (Berdegué 2005). Berdegué and Escobar (2002) have pointed out that because of the nature of rural poverty and the embeddedness of the rural poor in diverse livelihood strategies, agricultural innovation policies must differentiate among potential targets.

An important issue here is what parts various agents play in an innovation system and how they are linked to other agents. Paterson, Adam, and Mullin (2003) have proposed a practical approach to agricultural innovation systems that distinguishes between (1) the government functions of policy formulation, priority setting, allocation of funds and incentives, and regulation, and (2) the functions of financing, carrying out research, diffusion, creation of linkages, information transfer, and infrastructure, for which governments and innovation actors and stakeholders would share joint responsibility.

To conclude the preceding discussion on agricultural innovation policymaking, one could say that various newer theories suggest that policymakers, while they may draw from a possibly large set of information and analyses, should concentrate on setting broad policies on the macro level and deal with issues of priority setting and planning as well as financing and enable the collaboration and exchange of

information among various public and private agents in the generation and diffusion of innovation. On the local level, policies should provide strong incentives to innovation processes that involve local agents and knowledge and technology providers such as research institutions and advisory services.

2.3 Governance of Innovation Systems

Governance has been popularly defined as "the art of steering societies and organizations." This definition, though illustrative, falls short in two aspects: first, governance often can refer particularly to the strategic aspects of steering, that is, making the larger decisions about directions and roles; second, the term *steering* suggests that governance is a straightforward process that leads to predicted results, whereas in reality it is rather messy, tentative, unpredictable, and fluid and involves multiple actors and complex decision making (Institute of Governance 2006). Other definitions refer to "the state's ability to serve the citizens" (EC 2003) and the "traditions and institutions by which authority in a country is exercised for the common good" (World Bank 2004). The United Nations Development Program, considering governance as a complex strategic process, defines governance as "a system of values, policies and institutions by which a society organizes economic, political and social affairs providing for interactions within and among the state, civil society and private sector" (UNDP 2004). The variety in its definition marks the diverse use of the term in different contexts. The following subsumes some of the most important meanings that have been attached to the term:[3]

1. Governance in terms of changing and redefining the extent and form of state politics and public intervention (e.g., Fukuyama 2004), at times with the aim to minimize them (e.g., Peters and Pierre 1998).
2. Governance where the aim is to advocate principles of new public management or "good governance," including principles of participation, accountability, and efficiency and effectiveness, at times in the context of anticorruption measures (World Bank 2004).
3. Corporate governance, referring to the management and direction of corporate businesses (e.g., Clarke 2004).
4. Governance in terms of coordination of social relations and interactions, in companies or societies (e.g., Mayntz 1993; Kooiman 1993), at times in the context of power relationships and collective action among institutions (Stoker 1988).
5. Governance in terms of economic organization among firms (markets, hierarchies, and contracting) as suggested by Williamson (1985) and further developed to the concepts of coordination networks and informal social systems within firms and contractual relationships

[3] For an extended discussion on the taxonomy of governance see also Rhodes (1997) and Kooiman (2000).

between them that help to coordinate the generation of complex products or services in uncertain competitive environments (Powell 1990; Snow, Miles, and Coleman 1992) or within agricultural production chains (Zylbersztajn 1996, Birner and Wittmer 2006).

6. Governance as mechanisms of socio-cybernetic systems and self-organizing networks (e.g., Rhodes 1997; Birnbaum 2004, Haldenwang 2005).

   The need for governance exists anytime people come together as a group to accomplish an end.

As such, governance can be understood broadly as the process through which such a group makes decisions that direct the group's collective efforts (Institute of Governance 2006). If the group is too large to let all members personally make decisions, it creates an entity to which group members delegate decision-making responsibility. The group members constitute the stakeholders; they articulate their interests and influence how decisions are made, who the decision makers are, and what decisions are taken. The decision makers act upon the inputs from the stakeholders following the terms of delegation established; the decision-making units are then accountable to the stakeholders for the decisions they make and the outputs those decisions produce (see Figure 1).

Figure 1. Delegation and accountability in governance

Source: Institute of Governance (2006).

In the private sector the decision-making unit is an assembly of shareholders or a board of owners; in the nonprofit sector it can be a board of trustees or an assembly of stakeholders. Governments constitute decision-making units to which the society, after a selection process, has delivered decision-making responsibilities.

It is worth saying that it is not only governments that are involved in governance; governance refers to management of complexity, uncertainty, and interdependence within the relations between different levels and types of actors and political authority. The capacity of governments to independently affect change has been eroded by the emergence of powerful agents in the nongovernmental sector and the increased interdependence in complex networks of multiple agents whose coordination and management are increasingly problematic. In that respect Kooiman (1993) argues that the governing of a

society is a joint responsibility of all agents, not only governments but also semipublic institutes, private- and productive-sector entities, unorganized as well as organized, and official as well as unofficial. Governance, then, should be seen not as a property of those "officially" governing but as a quality of sociopolitical systems.

Related to this perception is actor-centered institutionalism (ACI), a concept that, drawing from policy analysis in public and semipublic sectors such as health, telecommunications, education, and research, argues that governance in those sectors is no longer adequately conceptualized by a clear dichotomy between the steering state and the society to be steered, and that top-down planning models treating "the state" as a unitary actor are no longer adequate (Mayntz and Scharpf 1995; Scharpf 1997; Mayntz 1998). Not only are both the steering state and the object of steering more adequately modeled as a plurality of actors, but the distinction between the two has become blurred altogether as state, public, semipublic, and private actors take part in and shape the "governance" of these sectors. In other words, ACI replaces the dichotomy of the "governor" and the "governed" by an analysis of actors' interaction in policy networks that can be characterized by multiple modes of interaction. ACI stands in contrast to North's (1990) thinking that institutions influence actors, for example, through opportunities, incentives, and mental maps. According to Scharpf (2000), actors and their interacting choices, rather than institutions, are the proximate causes of policy responses, whereas institutional conditions, to the extent that they can influence actor choices, are conceptualized as remote causes. Accordingly, ACI's perspective is how actors influence institutions, rather than how institutions influence actors. Without going further in this intellectual debate, it seems apparent that innovation systems policy is consistently linked to both the institutional change in the innovation system it tries to induce and the negotiation over and the decisions on new policies that institutional change is bringing about.

Governance has to do with making decisions about interventions that aim to improve the performance of individuals, organizations, and societies. Such interventions use instruments intended to affect the nature, types, quantities, and distribution of the goods and services provided in society. Traditional approaches to governance have emphasized a centralized approach focusing often exclusively on regulations, fiscal measures, and subsidies. Taxonomies for those interventions have been provided by many authors. Hood (1986), for example, groups interventions according to whether they rely on the use of information, authority, treasure, or the organizational resources of governments (see Table 1).

Table 1. A taxonomy of policy instruments (cells provide examples of instruments in each category)

Effectors	*Principal governing instruments used*			
	Information	**Authority**	**Treasure**	**Organization**
	Advice Training	Regulation User charges Licenses	Grants Loans Taxes and fiscal measures	Administration Public enterprise

Source: Adapted from Hood (1986).

Howlett (2000) classifies interventions such as those mentioned in Table 1 as "substantive policy tools" and contrasts them with more modern "procedural" tools designed to affect outcomes indirectly through the manipulation of policy processes and agent interactions upon the principles of participation, subsidiarity, and delegation. In fact, renewed interest in understanding the techniques of policy implementation in complex multiagent systems has led away from an exclusive reliance on command-and-control-oriented policy intervention tools as described above. In seeking to interpret and thus better understand the processes by which public policies are developed, scholars are gravitating increasingly toward explanations that hinge on our knowledge of the dilemmas associated with collective action (Sharpf 1997). Procedural tools for innovation policy also put in question the adequacy of the traditional and influential evidence-based policymaking model and the classic policy cycle, which considers steps such as identification of needs, consideration of options, policy formulation, institutional processes, policy deployment, and finally policy monitoring and evaluation before the cycle is entered again. Instead policy processes are put on the agenda that take account of the changing nature and variety of "problems" and the interplay of rationality, evidence, power, and compromise in decision making (Hagendijk and Kallerud 2003).

Policy interventions with regard to innovation often entail support mechanisms that can provide specialized services and information, including measures such as technology monitoring, research, educational provision, financial services, market research, and business planning (Hekkert et al 2007). Johnson (2001), setting forth a taxonomy of policy measures that aim at fostering innovation, argues that governments can (1) supply incentives for companies (and other productive agents) to engage in innovative work; (2) supply resources such as capital and human resource competence; (3) guide the direction of searches (influence the direction in which actors deploy resources); (4) ensure that actors recognize the potential for growth (identifying technological possibilities and economic viability); (5) facilitate the exchange of information and knowledge; (6) stimulate and create markets for new products and services; (7) reduce social uncertainty (i.e., uncertainty about how others will act and react); and (8) counteract the resistance to change that may arise in society when an innovation is introduced (provide legitimacy for the innovation).

Governance is important in public decision making concerning science, technological development, and innovation. The governance of an innovation system can be understood as the structures and procedures policymakers set forth to foster innovation and provide incentives to innovating agents and the interaction among them.

In many countries the governance of innovation systems has been characterized by a high degree of departmentalization, sectoralization of the political administration, and low interministerial exchange and cooperation (Smits and Kuhlmann 2002). A horizontally co-coordinated innovation policy, however, needs to ensure that the innovative agents make the best of their potential and that the system generates the most benefits to the various groups of the society that it has identified as priorities. In this vein, many scholars of innovation systems argue for an "incentive-based" approach in which the government guides innovating agents in the private sector by applying incentives but carries out less research and technology transfer on its own. Further, evidence from industrialized countries suggests that innovation systems governance should rely less on hierarchical control and reporting systems and more on flexible, decentralized management practices and open learning based on broader strategic objectives and principles of self-organization (OECD 2005).

There are particularities in the governance of innovation systems that differentiate it from other governance processes:

- Innovation systems have complex structures and evolve over time in an unplanned manner based on the principles of diversity, selection, and self-organization. As the outcomes of the innovation endeavor are only partly predictable, decision makers need to react flexibly and revise their decisions in light of new evidence.
- Decision makers need to manage large amounts of information to be able to judge the potential effects of innovations.
- Because of the many agents and processes involved, centralized control is impossible and innovation policy can influence the spontaneous development of innovations only to a limited extent (Chaminade and Edquist forthcoming).
- As the outcomes of the innovation endeavors are uncertain, decision makers need to plan for and optimize risk management mechanisms.

These particularities have wide implications for the style of governance: Decision makers have to take into account the existence of multiple agents who need to participate in priority setting and decision making. Decision makers need to deal with complex processes and limitations on control measures, which constitute a challenge to the development of a coordinated and coherent program. Finally decision makers need to be accountable under situations of increased risk, which requires them to be as well informed as possible about possible outcomes. Further, as activities directed toward the development of innovations

do involve many entities other than the central government, there is need for coordination and transparency between all the different actors to achieve coherence in their actions.

One commonly ascribes a normative component to governance—that is, we assume governing bodies consider democratic principles and socially desirable targets following the idea of "good governance." The idea of good governance introduces the dimension of correct and suitable decision-making processes—it is about decision-making units' efforts to achieve the desired results, in the right way. Since the "right way" is largely shaped by cultural norms and values held by organizations and the society, there can be no universal template for good governance.

In Europe, for example, the European Union has elaborated five principles to establish more democratic governance and improve the relevance of its institutions: openness, participation, accountability, effectiveness, and coherence (EC 2001). The United Nations, based on broad norms, has elaborated a list of nine characteristics of good governance of universal relevance—namely, the principles of participation, transparency, responsiveness, rule of law, consensus orientation, equity, effectiveness and efficiency, accountability, and strategic vision (UNDP 1997).

On the basis of the principles listed in the preceding paragraph, we present a number of norms and characteristics of good governance and policymaking that are relevant to the field of agricultural innovation:

- *Participation*. Agents affected by political decisions on agricultural innovation should participate in the decision-making processes and the development of meaningful criteria for setting priorities, designing policies, and channeling funds for agricultural innovation. Participation contributes to the exchange of information needed for effective decision making. It also helps to achieve legitimacy and create confidence in the end result and in the institutions that deliver policies. For agricultural policies this means that a possibly wide range of farmers and other people associated with agricultural value chains and rural territories as well as consumers should have a voice and be included in decision-making processes concerning agricultural innovation strategies and programs. Participation possibly can extend to the involvement of farmers in the generation of the knowledge and technology, which in turn ensures that the solutions developed are of use and adapted to local conditions while taking into account existing local knowledge.
- *Transparency and openness*. Transparency is achieved if all information regarding decision making on funding and priorities is open and freely available. This implies that central and regional governments and agricultural development agents actively communicate and deliver key messages to stakeholders about what they do and the decisions they take. They should use language that is accessible and understandable by the general public. Openness also implies that

potential beneficiaries such as farmers and processors have equal access to information and funding opportunities.

- *Responsiveness and accountability.* Those who govern organizations and societies, as well as the institutions and processes they establish, must be responsive to stakeholders. They must prove in some way that they are acting in response to stakeholders' priorities and generating outputs that respond to their needs. Accountability stresses that governments be austere and use efficient mechanisms to avoid corruption. Reporting on the efficient and effective use of project and program funds, as well as the ex post evaluation of outputs and impacts, helps to prove that funds are used in the best and correct way. In complex innovation systems the setting of priorities and use of funds involves various actors; however, despite any joint responsibility, it is usually those agents that disburse the funds who are held accountable.
- *Consensus orientation and coherence.* Differing interests need to be mediated to balance regional and subsectoral development, and the institutions involved in agricultural innovation need to reach a broad consensus on what is of general interest and who is taking which role in it. Coherence allows for coordination and the formation of critical innovation masses, but it also enables innovating agents to be competent. The need for coherence has become pronounced now that the range of tasks that need to be performed to achieve innovation-led growth in agriculture has grown. Central governments and public research and extension institutes and universities are not alone in creating agricultural innovations; such innovations are increasingly created with the participation of regional and local authorities and a range of civil society and nonpublic research, extension, and development agents. Coherence requires political leadership and a strong responsibility on the part of institutions to ensure a consistent approach within a complex system.
- *Strategic vision.* The government as well as the leaders among the various innovation-promoting agents need to have a broad and long-term perspective on agricultural development and change, along with a sense of what is needed for such development. This requires not only the identification of innovation and development opportunities but also an understanding of the historical, cultural, and social complexities in rural areas and among consumers. A strategic vision usually describes a set of ideals and priorities, a picture of the future—but the strategic vision is also a bridge between the present and the future, and it should be shared by the actors involved.

The governance norms and principles described in this list are mutually reinforcing and cannot stand alone. Yet one imagines that few policymaking processes will achieve complete compliance with them. Often, an orientation toward the norms is considered a first step in good governance; their guiding function can be more important than developing absolute measures of the level of good governance

achieved. In any case, one can use the norms described above to analyze the status of governance in a given context.

2.4 Illustrative Examples of Innovation Systems Governance

In this section we feature agricultural innovation systems in five countries to illustrate how innovation systems governance is carried out in concrete cases. The information has been collected from existing grey literature and evaluation and policy documents. Each case illustrates one of the following aspects of innovation systems governance: participation, transparency, responsiveness and accountability, consensus orientation and coherence, and strategic vision. The countries were chosen based on the criteria of (1) comparability with Bolivia regarding size or degree of development, and (2) being illustrative with regard to one of the five governance principles introduced in the previous section. The following cases were chosen:

- Nicaragua, whose system is characterized by diverse knowledge and technology providers and multiple funding sources in which farmers and producers have exercised a high degree of participation.
- Uruguay, whose system is characterized by strong, independent public research institutes with a solid funding base, and which through transparent operations integrates many other agents in the system.
- Senegal, which has strengthened demand articulation by local producers through a large organizational and capacity strengthening project, which in consequence led to a reorientation of research in the public national agricultural and food technology institutes.
- Sri Lanka, which suffered from a lack of coherence due to too many fragmented research and development efforts at various research and advisory service agencies and the lack of a central funding mechanism. Its latest efforts to restructure its system are pointed toward establishing an apex body with the mandate to coordinate innovation activities in the public and private sectors.
- Thailand, which recently reoriented research and extension under the frame of a knowledge and technology system, prioritizing strategically the area of organic production as the main focal point of innovation.

As a general remark, the analysis of common features of agricultural research and innovation systems in different countries allows us to notice how such systems' focus is evolving from national public-sector research organizations to institutions that emphasize a diversified public-private system in which clients, especially farmers, are key partners and participate in financing, planning, implementing, and monitoring research. Parallel to and consistent with these changes, research planning, monitoring, and evaluation have evolved from centrally driven top-down approaches to approaches that emphasize

decentralization and participation, in which client demands and satisfaction are key inputs. From the cases analyzed we can conclude that much progress has been made to enhance accountability; however, the research systems still face major challenges in ensuring that demand-driven approaches provide coherent research programs consistent with national policy objectives and in ensuring that they reflect the interests of the poor.

Nicaragua: Broad Participation of Knowledge and Technology Providers and Diversification of Public Services

The Nicaraguan agricultural sector experienced wide policy shifts over the last two decades. State intervention during the Sandinista period (1979 to 1990) was reversed by subsequent governments that drastically reduced credit, curtailed government technical assistance services, and liberalized foreign and domestic markets for agricultural inputs and outputs.

In 1993, with World Bank assistance, the government articulated a comprehensive development strategy that included the Agricultural Technology and Land Management Project (Government of Nicaragua 2005). The Nicaraguan Institute of Agricultural Technology (INTA) was created to provide advisory services to farmers, and experimented with cost-sharing strategies (Keynan, Olin, and Dinar 2001). A Directorate of Agricultural Technology (DTA) was created within the Ministry of Agriculture and Forestry (MAG-FOR); it designs and implements technology and training policies and coordinates and monitors publicly funded research, technical assistance, and training activities.

The Fundación Nicaragüense de Tecnología Agropecuaria (FUNICA), a semipublic funding and planning body accountable to a board of directors that brings together public and private stakeholders, serves as a permanent forum for discussing and agreeing on technology, setting priorities, and channeling funds. FUNICA manages a competitive fund facility with two windows: the Support Fund for Agricultural Technology Research in Nicaragua (FAITAN), which finances agricultural research submitted by domestic and foreign research organizations, and Fund for Technical Assistance (FAT), which stimulates competitive, private agricultural advisory services. In recent years efforts have been made to make FUNICA a forum for consensus building among public and private actors.

INTA is the main public institution responsible for the generation and diffusion of innovations. In the mid-1990s INTA adopted three main modules for service provision:

1. *Mass media and demonstrations (free of charge),* targeting small subsistence farmers producing basic grains and poultry who usually are characterized by no association with farmers' organizations, insecure land titles, and very limited access to credit and markets. These farmers are located primarily in marginal areas, with high climate risks, less fertile land, and no irrigation.

2. *Co-financed public technical assistance,* targeting farmers with development potential who produce basic grains, livestock, and other crops for both their own consumption and local markets. These farmers are characterized by secure land titles and access to informal credit and markets. They are usually located in areas with agricultural potential. Their farm income is sufficient to support a family, and they have good prospects of developing their farms further.
3. *Co-financed private agricultural assistance,* targeting commercial farmers producing nontraditional crops and livestock. Their land titles are secure, and they have access to formal credit and national and international markets. They are located in areas with high agricultural potential, and their level of organization is relatively high. The idea is that government subsidies to this type of advisory services will be phased out in due time.

The first two modules of service provision are provided by INTA, and the latter module by private service providers contracted by INTA through public bidding. INTA recently has refocused its activities away from advisory services toward (1) strategic and adaptive research; (2) technical assistance; (3) capturing agricultural technology and knowledge from foreign sources; (4) promotion of basic and registered seed; and (5) sourcing out services to other agricultural service providers.

However, FUNICA and INTA are not the only organizations that fund and carry out agricultural research and innovation; in addition to those public institutions are numerous government programs aimed at fostering competitiveness and local development as well as development agencies and donors that fund research, capacity strengthening, and technology transfer. In addition, numerous institutions exist to carry out those activities, including research institutes at universities, international consultants and universities, NGOs, community-based organizations, local consultancy companies, and producers and their associations. Hartwich et al. (2006) found that Nicaragua has many institutions and an important infrastructure for agrifood research and innovation, but those institutions appear underfunded and insufficiently connected with one other and to the productive sector, especially the small-scale farmers and larger-size entrepreneurs. Analyzing 12 agricultural subsectors, Hartwich et al. revealed the following:

Various institutions promote innovation and set policies in the context of agricultural and rural development, economic development, or science and technology and higher education. Yet the resulting policies do not provide a common framework for agricultural innovation, and there is no common source for funding of innovation activities. In part, INTA, the University Institute NITLAPAN, and the Institute of Rural Development (IDR) foster research and, less prominently, extension in the more traditional sectors, while the Commission for Competitiveness (CPC), the Ministry of Finance, Industry, and Commerce (MIFIC), and some development cooperation programs are the leading promoters in the more modern sectors and higher-value products where innovation rents appear to be higher. This fragmentation

of responsibility has led to gaps in the promotion of innovation in primary production in nontraditional sectors, and especially in processing and postharvest in traditional sectors.

1. *Sources of funding*: Few subsectors have sufficient support from the public sector for innovation development. Funding is primarily from a development cooperation or drawn by the government from the budgetary aid provided by international development banks. The private sector is an important source of funding for innovation when it imports technologies, commissions consultancies that provide access to knowledge from abroad, and travels to foreign countries and learns about new ways of doing business, although this holds only for the more advanced subsectors studied. However, the private sector does not only invest in nontraditional sectors, such as shrimp and peanuts, but also in traditional sectors such as dairy and coffee.
2. *Sources of innovation*: Important agents that generate innovations and likewise help in the diffusion and development of joint learning spaces are development and international research agencies and consultancy companies, followed by input-providing companies (seed, feedstuff, machinery), enterprises that import technologies, and, to a less extent, agricultural producers and local research centers and universities. The government, especially from the side of the Ministry of Agriculture and the sector development program PRORURAL (Nicaraguan Government 2005), tends to ignore these sources and emphasizes certain research and technology transfer centers, such as the Nicaraguan Institute for Agricultural Technology (INTA), the Institute for Rural Development (IDR), the National Institute for Technology (INATEC) and some universities. INTA plays a substantial research role in some traditional subsectors with many resource-poor farmers. However, the government extension and technology transfer system promoted through INTA seems overburdened by the task of reaching the main portion of producers and dealing with all the different issues around agricultural innovation; development cooperation projects and NGOs are taking over a very important part of this role. Overall, it appears that producers have insufficient access to the primary and complementary sources of knowledge and technology needed to develop innovations, either because access is monopolized or unavailable or because the source is simply not known.
3. *Linkages between innovating agents*: International research and development agencies and their consultants dominate agricultural research and technology development in Nicaragua; they also enable connection among various agents. Within such projects efforts are made to reach out to agricultural producers. In fact, today many internationally funded technology transfer, research, and development projects require strong participation of the private sector and connection with local research and development agencies. National research centers and universities tend to have weak links with the productive sector, be it either to small-scale producers or, even more so, to

commercial farmers and processors. Most of the links public institutions maintain with the private sector continue to follow the linear model of technology transfer, which suggests that inventions generated by researchers can be easily handed to the producers. They provide only for sporadic exchange of information and do not allow for mutual learning. Some subsectors, in fact the more innovative ones, are characterized by much stronger linkages among the various agents, including international and national research, policy environment, development cooperation, and the productive sector.

4. *Innovation:* Many agricultural subsectors in Nicaragua still have not absorbed sufficiently modern knowledge and technology to enable producers and processors to reach sufficient levels of income, improve their livelihoods, and compete regionally and internationally. However, different subsectors vary greatly, which in part can be explained by (1) the availability of suitable innovative solutions that fit producers' absorptive capabilities; (2) the connectedness of productive agents to knowledge and technology providers, markets, and other (innovative) producers; and (3) the availability of support from government and particularly development agencies.

Through recent years public institutions such as INTA have tried to reposition themselves in a less centralized innovation system that grows constantly in diversity. The idea is that in a system where various actors can offer research and advisory services, the public sector should concentrate on creating a policy and regulatory environment and improving the quality of services that only government can offer. In this context Keynan, Olin, and Dinar (2001) suggest that INTA's role should include (1) research on public goods and strategic programs of national interest; (2) serving as the agricultural technology issue "think tank"; (3) becoming the agricultural sector technology bank and diffusing technologies to service providers; (4) involving local stakeholders in setting research agendas; and (5) maintaining strong linkages with international institutions and networks associated with the Consultative Group on International Agricultural Research. However, INTA does not necessarily need to be involved in providing extension services, particularly in those areas where it does not have the expertise—for example, in production of crops it has not been working on and processing and postharvest technology. In any case it should stay away from funding and overall priority setting for national agricultural development as these roles should be filled by government bodies on a higher level.

In conclusion, the Nicaraguan case shows us how in an innovation system with diverse actors government research organizations don't necessarily have to concentrate on all research and innovation work because (1) in some areas they are not necessarily the most efficient providers, and (2) they don't have the capacities to do it all. Given a diverse structure, however, government and development organizations should foster more prominently network-like interactions in which complementary sources

of knowledge, including producers, engage in priority setting and development of sector-specific innovations enabling dynamics of joint learning. Innovation networks help guarantee that productive agents participate in the development of innovations, that the technological solutions generated respond to market conditions and demands, and that the various options available on the national and international level are taken into account. Networks can also enable the diffusion, adaptation, and adoption of technologies through innovative producers, a function that the current extension system does not sufficiently fulfill.

Uruguay: Transparency and Openness in a System Dominated by an Independent Semi-public Research Institute

With an area of 176,215 square kilometers and a population of 3.2 million, Uruguay is one of the smaller countries in South America. Uruguay has traditionally been an exporter of agricultural products. In 1993, 13 percent of the working population was employed in agriculture, but agricultural exports nevertheless accounted for more than half of total exports. The two main export products are meat (especially beef) and wool. The principal crops are rice, wheat, and barley. Citrus, sorghum, and sunflower are increasing in importance.

The Uruguayan National Agricultural Research Institute (INIA) was created in 1989 as a legal entity that, although publicly owned, has the freedom to set its own operations. For example, INIA selects its staff, decides on its own management procedures, and signs contracts and agreements with private national and international entities. The institute is governed by a board of directors, with two members from government and two from farmer organizations. Farmers contribute about 50 percent of its budget through a levy (0.4 percent) on the sale of agricultural products. The government, by law, is obliged to provide a matching contribution.

In 1997, INIA staff totaled nearly 500, including 142 professionals (including 46 doctorate holders and 63 Master of Science holders). Staff is assigned to administration or among the 11 national programs, which include winter crops, summer crops, rice, beef, milk, sheep, pastures, farm animals, horticulture, fruits, and forestry. The institute has five research stations, totaling more than 5,000 hectares, one in each of the five regions into which INIA has divided the country. Each region has an advisory regional council that consists of representatives of agricultural organizations in the region and knowledgeable technicians and producers. The functions of the councils are being reviewed to strengthen their performance. Specialized working groups within the councils address specific topics of concern in the regions. Each working group, moreover, has a coordinator responsible for ensuring optimum communication with the council.

Through an ongoing process of consultations, particularly with farmers, INIA defines certain areas of research as priorities. It maintains some 90-plus memoranda of understanding with different associations and private-sector organizations. Total research funding has increased, and the institute has developed a good reputation for its research. One key to success has been strong links to clients through decentralized research stations with regional advisory councils of farmers. Commodity working groups, roundtable consultations, and a technology diffusion unit further strengthen relations with clients. Uptake of research results is not achieved through a large extension service; rather, in the specific context of Uruguay, producers and their associations actively search for and demand information on technology. INIA's projects therefore are oriented more toward research and development than to technology transfer, although it invests intensively in communication and diffusion of results. Further diffusion of knowledge and technologies is supported by the Instituto Plan Agropecuario.

INIA carefully screens which work it can and wants to do in-house and which initiatives could be better done by individuals and organizations outside the institute, for which cases it has the Fund to Promote Agricultural Technology (FPTA). In fact, 10 percent of the institute's research budget is set aside for competitive contracting for research with outside agents (Negro and Grierson 1999). Universities receive almost half of this funding. Another strategy is to invite partners from other countries in the Latin American region, principally through the Cooperative Program for Agricultural Technology Development in the Southern Cone (PROCISUR, from sources such as the Regional Fund for Agricultural Technology (FONTAGRO) of the Inter-American Development Bank which encourage the contribution of recognized regional and extraregional research centers.

FPTA has been instrumental in the creation of a national system of relationships and interactions, which has brought about a continual flow of information and a capacity to transform scientific research to practical solutions. FPTA encourages research to produce practical results in the short term. It has tried to respond to a fairly immediate demand for technical solutions. By maintaining a balance between the projects funded through FPTA and its own research, INIA can build its own capacity, make at times strategic use of the capabilities of other organizations, and help form and maintain a coherent NARS. Effective linkages have led to research partnerships between universities and INIA. For example, in some cases university and institute staffs annually to prepare joint research programs, senior INIA staff spend up to 20 percent of their time teaching at universities, and university students receive fellowships from INIA.

The functioning of the system dominated by INIA relies strongly on transparency in its operative instruments (Hobbs et al 1998). INIA therefore strives for clarity in its rules for co-financing, degree of reimbursements, and rules covering intellectual property rights. It demands detailed agreements among partners when projects are executed in partnership. It diffuses information openly about professional

salaries and limits them to ensure that resources are not spent primarily to finance increases of the executor's personnel. For purposes of accountability, every project is monitored and supervised at different levels: first, an evaluation committee s the project counterpart monitors and technically evaluates the project; second, the financing and administration units monitor and control budgetary disbursements; and finally, the project's unit provides overall coordination.

In 1998, the Inter-American Development Bank (IADB) financed a new operation, introducing several features designed to incorporate more competition and transparency into the system. The objective was to diversify the structure of financing that depended heavily on public resources and to strengthen the overall innovation technology system by increasing the participation of beneficiaries. All proposed research projects were classified into strategic and applied projects. Strategic projects were funded via block grants but reviewed by panels composed of national and international members, and approved to be executed by INIA.

The national agricultural innovation system is made up of additional public research organizations, such as the Uruguayan Food Technology Laboratory (LATU) and the Faculty of Agriculture of the Universidad de la República (FAGRO). FAGRO, among other things, maintains 14 roundtables on agricultural technologies that do not correspond to INTA's programs but are harmonized with them. The roundtables bring together agents from the public and the private sectors as well as from research and technology transfer and help in orienting research and development activities. Other roundtables are managed by INIA. Other funding opportunities exist through the National Fund for Science and Technology.

Policy bodies that steer the national innovation system are the Dirección General de Servicios Ganaderos/Agrícolas in the Ministry of Agriculture and the Dirección Nacional de Ciencia y Tecnología (DYNACYT). In April 2005 the Ministerial Cabinet of Innovation (Gabinete Ministerial de Innovación) was created to spur coordination among ministerial areas. In 2006 the National Agency for Research and Innovation was created; that agency is currently identifying strategies for funding the Strategic Plan of Science, Technology, and Innovation, which mainly fosters diversifying the support and incentives to new and alternative public research agencies and especially private entities while maintaining some strong programs of strategic research in the traditional institutions.

In conclusion, the Uruguayan case shows how in a small homogenous country whose agriculture is concentrated in a limited set of agricultural products a public research organization can take over the main responsibilities in orienting and carrying out research. Overall the innovation system's performance is prolific though there is critique that despite abundant and diversified research there is not sufficient priority setting and few research results are applicable. Sufficiently independent from government, through its legal status and a levy funding mechanism, INIA can attract and maintain capable and

motivated researchers and pursue its own agenda with sufficient flexibility. Yet it does collaborate intensively with other organizations in priority setting and carrying out research and opens up funding opportunities for them. To coordinate itself with other institutions in the agricultural research system, INIA tries to be transparent and open. It communicates priority areas and funding strategies, disseminates information on activities and results, and invites agents to build partnerships. INIA is also seeking its niche in the new Uruguayan innovation system, wherein it clearly will be only one player among many others, with a particular emphasis on research and development at and with private entities.

Senegal: Responsive, Accountable, and Financially Sustainable—the National Agricultural Research and Food Technology Institutes

Senegal administers one of the more advanced agricultural innovation systems in western Africa; however, an evaluation of the World Bank–funded Agricultural Research Project, completed in 1996, stressed that the Senegalese Research Institution (ISRA) was performing poorly. Despite considerable investment since the mid-1980s, with two successive World Bank and U.S. Agency for International Development (USAID) projects funding capacity strengthening and research, ISRA was still judged to be responding insufficiently to farmers' needs. Pending management reforms related to performance-based staff incentive systems and administrative reforms had not been applied. And badly required reorientation toward new subsectors and postharvest and processing technology had been neglected in the presence of an equivalently inefficient Food Technology Research Institute (ITA) (ISNAR 2003).

The analysis concluded that without strong demand from end users, ISRA and ITA were unlikely to make essential reforms to improve their research services. In response, a project was set up to (1) strengthen producer organizations' capacity to become effective research partners, and (2) establish mechanisms to make research institutions accountable to clients. The project established the National Agricultural Research Fund (NARF), a legally independent entity that—separating itself from executing research—funds and promotes research among public and private, qualified knowledge and technology providers (World Bank 2005). In parallel, government core funding provides ISRA and ITA with funds for infrastructure, training, and management (Dufaut 1999).

NARF finances research under two proposal mechanisms: researcher-developed proposals that correspond to ISRA's or ITA's strategic plans, and responses to calls for proposals issued by NARF on themes identified by end users. The two types of proposals undergo the same two-tier screening procedure: first, by a scientific and technical committee of 15 scientific resource persons (six from outside Senegal), who screen proposals for scientific quality, and then by a management committee made up of a majority of producer organizations and private-sector representatives. An executive secretariat

implements the decisions of the management committee. Once a proposal is approved, NARF signs a contract with the lead research institution.

Funding through core and NARF-contracted research guarantees continued institutional development; operating costs go directly to research teams. In return, the teams are accountable for results. Projects are screened rigorously. Only 26 of the first 79 research proposals were approved. Projects promote broad collaboration among organizations with research capacity (85 percent of projects); international organizations (12 percent); and development agencies, such as producers' organizations, NGOs, or others (58 percent). Overall, 38 institutions have received funding under the 26 projects.

Under a new set of government funding strategies, the Ministry of Finance set forward a policy that government funding must cover the fixed costs of research institutes, which can no longer be financed by international development assistance funds. This caused the government to recognize that it could no longer afford to support ISRA's extensive research infrastructure and that closing redundant facilities was inevitable.

In conclusion one finds that Senegal has had success in reshaping its agricultural research so that it responds to producer demands; Senegal has made a substantial effort to help producers organize and articulate demand. Senegal has developed intelligent funding mechanisms that oblige researchers to either respond directly to the demands of producers or develop activities in certain prioritized areas. Government funding now guarantees the financial sustainability of Senegal's research institutions. Interestingly, Senegal established new dynamics in research by establishing a management committee with a majority of user representatives.

Sri Lanka: Lack of Coherence through Fragmentation and no Collaboration

Sri Lanka covers an area of about 66,000 square kilometers and is characterized by diverse agro-ecological zones that reach from the coastal lowlands to the central highlands which rise more than 1,500 meters above sea level. The climate is tropical with little seasonal temperature variation. Estimates from 1982 show that nearly 65 percent of all agricultural holdings were under 2.0 acres (0.8 hectares) in extent, covering about 16 percent of the agricultural land area. The total number of agricultural holdings increased by 90 percent between 1946 and 1982, and the increase in area cultivated increased by 25 percent. Preliminary data from the 2002 census indicate that the number of holdings increased by another 80 percent, and that more than 40 percent of holdings were under one-quarter of an acre. Rice is by far the single most important crop cultivated in the country. It contributes nearly 25 percent to the agricultural GDP. Vegetables follow with about 20 percent, followed by coconut (13 percent), tea (12 percent), other food crops (10 percent), other export crops (5 percent), and animal husbandry (5 percent). The remaining 10 percent is made up by other crops, forestry, and fisheries.

The agricultural sector, overall, contributes 18 percent to Sri Lanka's GDP. Many of the country's poor live on smallholdings and depend for part of their incomes and a larger part of their livelihood on agriculture. Smallholdings often cannot generate sufficient income to support a farm family; however, there are cases where diversified agriculture, consisting not only of rice but also vegetables, livestock, and fruits, provides farm families with a better living. Important constraints to more intensive and diversified farming are a lack of working capital or access to credit and poor access to markets and sources of knowledge.

Agricultural research in Sri Lanka faces the challenge of making agricultural development more sustainable and more equitable. Sri Lanka's agricultural research and extension system is very fragmented, reflecting the substantial fragmentation of the government in general. At present, of a total of 53 ministries, some nine deal with agriculture and rural development—among them, the Ministry of Agricultural Development, the Ministry of Estate Infrastructure and Livestock, the Ministry of Coconut Development, and many others (Amarasekara 2006), nearly all of which are involved in some type of agricultural research or extension. In addition, there are eight provincial councils that run provincial extension services, a Ministry of Education that deals with the university sector (including various faculties of agriculture), and a Ministry of Science and Technology that sets science and technology policies and provides funding, some of which is of relevance to agriculture.

The government is the principal source of funding for agricultural research. More than 80 percent of the total budget requirement is provided by the state directly through the Treasury and indirectly through project-specific competitive grant schemes such as the Council for Agricultural Research Policy (CARP), the National Science Foundation (NSF), and the National Research Council (NRC). However, the size of government budget provisions is inadequate relative to the research agenda. Due to cost escalations in research-related equipment/expendables and an increasing wage structure, there is little left over for research expenses and maintenance of common facilities at the existing research institutes after salaries and wages are paid (they take about 80 percent of the budget). This is of even more concern given that recent years have seen a declining trend in budgetary allocations. In the past, funding packages from external development sources were quite substantial but are now limited in size, short term in nature, and not always consistent with the public agenda (Senanayake 2006).

Problem identification and prioritization is conducted following a "bottom-up" approach: informal working group meetings with farmers and other stakeholders are convened every six months by the provincial extension agencies. To this participatory agenda, the government is adding themes of national importance, such as food security and increasing the competitiveness of the export market for agricultural commodities in the global economy. However, the system is not responsive enough and provides too little support for the adoption of available technologies (both locally generated and

imported). In particular, it is not able to integrate the fast-growing private sector, which shows capacities in processing and value addition of agricultural products (Fernando 2006).

The government and the Sri Lankan Council for Agricultural Research Policy are aware of the incoherence in the system. A recent evaluation revealed that the system suffers from (1) fragmentation and the placing of various subsectors and subjects of the agriculture sector under several ministries/sub ministries; (2) the absence of an apex body with the overall authority and mandate to coordinate, at the national level, policy planning, research planning, priority setting, the monitoring of research progress, and the mobilization and program-based allocation of resources for research and development; and (3) the absence of formal linkages between related institutes/departments within the research system as well as between research and extension components (Sivayoganathan 2006). The Sri Lankan government, with the World Bank's support, is currently exploring possibilities to mend the fragmentation, the lack of integration, and the limited involvement of the private sector. The objective would be to increase the market orientation and innovation potential of the system.

In conclusion we find that the Sri Lankan agricultural research and innovation system consists of many research departments/institutions with well-defined mandates that are capable of catering to the technology needs of farmers in various agro-ecologies, consumers, and markets. But the overall efficiency and effectiveness of this system is jeopardized by the lack of a central funding and coordination function. Sri Lanka is trying to address these problems with a new strategy of bringing all efforts together under a national agricultural innovation framework with an apex body that provides priorities, incentives, and funding for collaboration in innovation.

Thailand: Autonomy and Strategic Vision Encompassing Organic Agriculture

Thailand has recently experimented with government policies designed to foster a knowledge-based economic and social system. The Thai government and private sector, as well as others in the country, are concerned about the country's declining ranking in the global technological capacity sweepstakes. In fact, policymakers have recognized the importance of innovation as a determinant of Thailand's future competitiveness on international markets. They perceive that innovation must be nurtured and harnessed as a priority strategy to achieve national development by leaps and bounds—that is, radical as opposed to incremental innovation.

In 2003 the Thai cabinet endorsed the creation of the National Innovation Agency (NIA); the agency is an autonomous organization that is supervised by the Ministry of Science and Technology and guided by a National Innovation Board but resides outside the framework of the civil service. NIA constitutes an umbrella organization that facilitates different types of cooperation between firms, private knowledge and technology providers, and public institutions on the local and national level. It also fosters

linkages with different actors in academia, technical production, finance and investment, and management. NIA weaves together technology, marketing, and finance to ensure that "near-market" innovative ideas actually make it to the production line. NIA puts particular emphasis on fostering cluster-based innovation (Lorlowhakarn and Ellis 2005).

To accelerate innovation capability in key sectors, NIA has focused on strategic innovation in three main areas, namely, bio-business (i.e., biotechnology, bio-based materials, and natural products), energy and environment, and design and branding. The Thai government recently endorsed a policy in support of organic farming, announcing in a cabinet resolution in 2005 the ambitious goal to transform Thailand's agriculture by increasing the importance of organic production systems (Pun-arj 2003). On the same path, NIA embarked on a new program involving local producers, government agencies, and other key stakeholders to develop innovations to further stimulate Thailand's organic agriculture. The program focuses both on specific product- and process-based innovations and on their integration into the national strategy of agricultural development. Pressure on Thailand's agricultural sector has recently increased due to (1) the establishment of bilateral free trade agreements that cause net imports of cheaper agricultural products from abroad and reduced farm incomes, and (2) the introduction of the European Food Law provisions for traceability and residue levels, which further restrict access to export markets, particularly for smallholder farmers with limited access to capital, information, and (especially) the management skills needed to comply with the new rules.

The concurrent expansion of the organic sector has helped to some extent to alleviate this pressure, but organic production still represents a relatively small niche with low levels of productivity and little knowledge and technology available to improve operations. At present, there are approximately 4,000 hectares of certified organic production in Thailand (1 organic hectare for every 800 hectares of farmland in Thailand). There is, however, considerable room for expansion and opportunities for smallholders to add value to their production and stabilize on-farm incomes, thus increasing agricultural exports and contributing to health and the environment through reduced dependence on high levels of chemical inputs.

NIA sees strong potential for innovations in organic farming in Thailand, along the whole supply chain—from product (varietal characteristics, e.g., color, flavor, texture, size) through to cultivation systems (e.g., new organic methods, bio-fertilizers, bio-pesticides), processing, packaging, transport, and marketing channels, including innovations in traceability and certification systems. The National Organic Model will focus both on the supply side—by encouraging smallholder farmers and small-to-medium-sized enterprises to enter the sector (e.g., by assistance in achieving compliance with regulations and protocols, and on shortening the supply chain to maximize grower margins)—and on the demand side—by stimulating demand for Thai organic produce through higher brand awareness and consumer

confidence. The model's overall goal is to integrate existing initiatives, encourage the adoption of innovations in products and processes, stimulate growth in domestic and export markets, and effectively channel political and institutional support to enhance stability and national competitiveness in the organic sector.

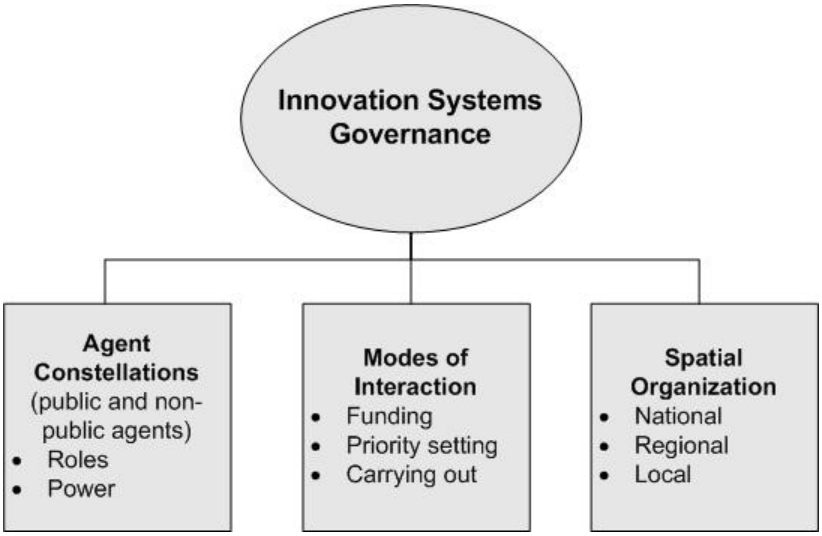
In conclusion, one finds that Thailand, applying a market-oriented innovation strategy, has set strategic priorities in organic agricultural production. The decision was based not only on the influence of stakeholders, who would rather have prioritized traditional agriculture, but also on visionary development thinkers. Pushing the decisions through to realize the vision did not depend on the government but on a semiautonomous agency fostering agricultural innovation that, among others, fosters linkages among innovating agents. The autonomous status of this agency has proven useful in gaining credibility among the various private stakeholders to act as an independent broker and communicate the strategic vision for the development of the sector.

3. METHODS

The study is an analysis of innovation systems governance—in particular, we examine how the government and other decision makers of institutions in agricultural innovation have governed the Bolivian agricultural innovation system and draw from this analysis general lessons for innovation policymaking in developing countries. As section 2 demonstrates, the literature suggests a wide range of measures to capture quantitatively the various aspects of governance, including indicators that measure not only accountability, participation, and corruption but also degrees of decentralization, gender equality, and press freedom. However, little attention has been paid to governance modes and indicators related to policies and measures that foster innovation and interaction among the poor in developing countries.

This study makes use of the concept of actor-centered institutionalism, arguing that governance incorporates and integrates three dimensions (see Figure 2): First, government and non-government actors are analyzed with regard to their different actor constellations depending on roles and power positions, mandates, and strategic visions. Second, the study analyzes to what extent the system enables interaction on the issues of priority setting, funding, and the carrying out of research, extension, and innovation activities. The spatial organization of the system is included as a third analytical dimension to illuminate to what extent governance promotes activities on the national, regional, and local levels.

Figure 2. Categories with which to study innovation systems governan



Three research questions formulated on the basis of the three dimensions of the methodological framework are as follows:

1. What main parameters have characterized the agent constellations in Bolivia's agricultural innovation system regarding the roles agents take and the power they exercise?

2. How do policymakers ensure the coordination and delegation of interactions and how do stakeholders participate in the priority-setting and funding activities and the actual carrying out of projects and programs that foster innovation?
3. How is the innovation system organized spatially? Are local, regional, and national agents and priorities sufficiently reflected?

The approach undertaken in this study is explorative and based on a case study of the Bolivian agricultural innovation system, which was analyzed in its different stages across time. The study approached the analysis of agent constellations by analyzing documentation describing the strategic orientation and functions of agents, administrative procedures for their operations, and results from evaluations of programs agents involved. To complement that information, we undertook interviews with the various types of agents participating in the system. The interviews were aimed particularly at the collection of data for the second dimension, modes of interaction, and the way those modes enable funding, the setting of priorities, and the carrying out of innovation projects. The guiding questions used for the interviews follow the principles of innovation systems governance developed in section 2 (see Table 2).

Table 2. Governance principles and guiding questions for understanding interaction in funding, priority setting, and the carrying out of innovation activities

Principle/Parameter	*Guiding Questions*
Participation	In what way have farmers and other users of innovation as well as those funding and promoting innovation participated in decisions on priorities, the distribution of funds, and the carrying out of research and innovation activities? To what extent did they contribute to the co-financing of SIBTA's activities? What kinds of participation mechanisms have been used?
Transparency and openness	To what extent have innovation users and stakeholders been informed about priorities and decisions made, the use of funds, and advances and results in innovation projects? What means are used to facilitate the flow of information among the different agents?
Responsiveness and accountability	Have decision makers responded satisfactorily to the needs and priorities of innovating agents? Have decision makers justified their decisions and rendered account on the use of funds?
Consensus orientation and coherence	Were decisions regarding funding and priority setting made with the agreement of all stakeholders involved and affected? Did these decisions foster collaboration and coordination among the various agents involved?
Strategic vision	Was a strategic vision elaborated and shared among the various agents and stakeholders? Were innovation projects and programs developed under a specific sector and innovation development strategy? Who has contributed to developing a strategic vision?

The questions shown in Table 2 were applied in semi structured interviews with representatives of the various agents involved in Bolivia's agricultural innovation system or well-informed key actors in institutions that operate within the system or collaborate with it. Further, the interviews were used to collect information on the involvement of national, regional, and local priorities and agents.

To complement this type of qualitative data, we analyzed quantitative relational data from the Bolivian SIBTA, that is, information on how agents relate to other agents in the innovation system. Relationships were quantified with regard to the functions of "priority setting" and "funding." The information for this type of quantitative analysis was collected in an expert consultation and a number of interviews with key actors. Based on these data, matrices of relational data were developed that depict the intensity of the relationships the different agents maintain, one for each of the aspects of funding and priority setting. The parameters were graphically illustrated in network maps that show the strength of linkages among agents—for example, who is how strongly funding whom, or following whose priorities.

Data collection was carried out from October 2006 to February 2007. Overall 75 key actors in SIBTA were questioned with regard to issues of system governance (see Table 3).

Table 3. Organizations and individuals interviewed

Type of organization	*Number of individuals interviewed*
Technology and Health Unit (UTS), Ministry of Agriculture (MDRAyMA, former MACA)	1
UCPSA	1
Vice ministry of Science and Technology (newly established and formerly not involved in SIBTA)	5
Four regional foundations for agricultural technology development (abbreviated FDTAs in Spanish)	17
Semipublic research centers (CIAT and PROINPA)	10
Technology transfer agents (NGOs, private consultancy companies)	10
Donor agencies providing funds to SIBTA	8
Farmers' associations participating in SIBTA projects	20
Universities	3

4. STUDY CONTEXT: BOLIVIA'S AGRICULTURAL TECHNOLOGY SYSTEM

The Bolivian agricultural innovation system consists on the one side of a government program, the Bolivian System of Agricultural Technology (abbreviated SIBTA from the Spanish), and on the other of many independent efforts among producers, civil society organizations, associations, NGOs, government programs, and donors (see also Gandarillas et al. 2007). The following analysis considers SIBTA as part of the agricultural innovation system and includes agents in SIBTA's environment that are not part of SIBTA. However, it does not cover the entire agricultural innovation system.

SIBTA has been funded to a large extent by the international donor community. SIBTA's main function is to channel funds to various semipublic and private knowledge and technology providers (called proveedores in the local terminology) in order to respond to the local demands of resource-poor farmers. The program follows the principles of demand orientation, poverty alleviation, and decentralization. SIBTA was designed to be semiautonomous; however, the government, in particular the Ministry of Agriculture, has had a strong responsibility in strategic orientation and priority setting that it has not always complied with to a full extent. Funding sources include a loan from the Inter-American Development Bank and a group of donors that includes the Danish International Development Agency (DANIDA), the Department for International Development (DFID), the Dutch Embassy, the German Agency for Technical Cooperation (GTZ), USAID, Japan, and the Swiss Agency for Development and Cooperation (SDC). SIBTA's objectives are to:

- alleviate rural poverty, by increasing producer incomes and ensuring food security for the rural population;
- increase the sector's competitiveness, by providing modern and efficient technology packages;
- contribute to the sustainable use of natural resources, by implementing innovation projects corresponding to national strategies; and
- assist in modernizing the institutional association of rural producers so as to build a base for the process of demand-oriented technological innovation.

4.1 Antecedents of SIBTA's Creation

Compared with other South American countries Bolivia still has the largest share of rural population and the highest percentage of rural people living below the poverty line (Arias and Bendini 2006). It is estimated that in 2002 poverty affected 83.5 percent of the rural population and 63 percent of rural dwellers were living in absolute poverty on an income of less than US$1 a day (INE-UDAPE 2002). In certain rural areas, poverty levels reach as high as 90 percent. The agricultural sector still maintains a high 17 percent contribution to GDP and accounts for nearly 35 percent of all exports. Agricultural exports

primarily consist of soybean, grains, cotton, sugar, and coffee. Imports of foodstuffs are high, particularly wheat and dairy products. Agriculture has expanded in some parts of the lowlands, encouraged by the high returns for soybeans, but little expansion has occurred in the rest of the country. Yields and productivity remain among the lowest in Latin American agriculture, particularly for staple crops.

Given the challenges in agricultural development and its importance for poverty alleviation, the Bolivian government and donors have long made substantial efforts to develop agricultural research and extension activities, with mixed success. In the 1950s Bolivia, with support from the United States and other countries, embarked on an agricultural development scheme in which an agricultural service, the Servicio Agrícola Interamericano (SAI), was responsible for both research and extension. SAI, in the mid-1960s, faced serious budgetary constraints due to unsustained government and donor funding. As a consequence, many of the best-qualified researchers left and the infrastructure began to deteriorate (Godoy et al. 1993).

Support to agricultural research and extension revived in 1975 with the creation of the Bolivian Institute of Agricultural Technology (Instituto Boliviano de Tecnología Agropecuaria, or IBTA) and the Tropical Agriculture Research Center (Centro de Investigación Agrícola Tropical, or CIAT),[4] the latter serving particularly the Santa Cruz region. Both organizations followed the same technology transfer model: research was carried out at experimental stations to identify new and more efficient and adapted varieties and crop management practices; identified technologies were then to be transferred to farmers by the institutes' extensionists, together with technical assistance and at times subsidized farm inputs.

During the 1980s IBTA's less effective extension service came under scrutiny, and given the tight financial situation it was significantly reduced. During the same time CIAT handed over extension functions to an independent Rural Development Center, which never became fully operational and closed in 1987 (Thiele et al. 1998). In the 1990s, in consequence of a World Bank loan that propagated a model in which farmers would search for and adopt knowledge and technologies on their own, IBTA's remaining extension offices were closed. In 1994 the Popular Participation Law (Ley de Participación Popular) was introduced, which led to a more relevant role for municipalities, although few municipalities have so far introduced agricultural technical assistance components (Bojanic 2001). The law also granted the municipalities access to government funding, creating space for initiatives to provide basic services such as health care, education, and infrastructure including rural roads and small irrigation systems. Few municipalities have taken advantage of this and set up an agricultural department to assist farmers with their technical problems, thus filling the gap of an inexistent extension service.

[4] In this document CIAT refers to the Bolivian agricultural research center for the lowlands, and not to the International Tropical Agricultural Center (Centro Internacional de Agricultura Tropical) of the Consultative Group on International Agricultural Research (CGIAR) based in Cali, Colombia.

During the 1980s research activities at IBTA were given a higher priority. A US$21 million loan the country received in 1991 from the World Bank was earmarked for strengthening the country's agricultural research capacity, but after the depletion of those funds the government could not identify sufficient funding sources to sustain the former level of activities. Underfunding and management problems caused by political intrusion, patronage and the consequent loss of motivation of staff led to further deterioration. Finally the inability to prove that investments were leading to the adoption of improved practices among farmers invoked the closure of IBTA in 1997. The main emphasis at IBTA was given to the postgraduate training of researchers; most of them became unemployed after IBTA's closure.

After the passage of the 1994 decentralization law IBTA's research infrastructure was handed over to departmental governments, where it often further deteriorated. With the closure several germplasm collections (e.g., in camelids, sheep, and native grasses) were lost. Only the potato and tuber crops development program survived the closure, as it was handed over to the newly established semipublic Foundation for Research and Promotion of Andean Crops (Fundación Boliviana para la Investigación y Promoción de los Cultivos Andinos, or PROINPA), which counted on SDC for financial support (de Franco and Godoy 1993). PROINPA later set up a larger quinoa program that again put to use the quinoa germplasm collection. The Pairumani Center for Phytoecogenetic Research (Centro de Investigaciones Fitoecogenéticas de Pairumani, or CIFP) has become another center of excellence; since 1972, with funding from the Fundación Patiño, it has done work on the genetic improvement of maize and pulses, germplasm banking, and seed production.

After the phasing out of funds and IBTA's subsequent closure, as well as the de facto dismantling of the extension system, the government, together with the country's active development cooperation, pursued a radical new approach to agricultural research and extension—decentralized and in response to existing demands of smallholders. Discussions began in 1998, when the government held negotiations with the Inter-American Development Bank to reestablish the idea of cost centers within the national system of research and technical assistance. Given some of IADB's restrictions, the Bolivian government invited various bilateral agents to contribute to the design of a transparent, decentralized, and demand-driven system that would allow for technology transfer to the country's poor and small farmers. After some eight months of intensive discussion and design in 1999 an agreement was hammered out between the government and donors that constituted Bolivia's first sector-wide approach in the agricultural sector, and in 2000 SIBTA was created.

4.2 SIBTA's Agents, Interaction among Them, and the Rules of the System

In an innovation systems context, SIBTA can be described in terms of its agents, their interactions, and the existing rules, as described in this section. SIBTA brings into play a diversity of agents contributing to

the generation, diffusion, and application of innovations. Some agents form part of an institutional setup, whereas others stand on their own or remain on the periphery of the system. The main types of agents are described as follows. Figure 3 illustrates the hierarchy among the agents.

- *Government.* In the Bolivian government the main responsibility for SIBTA is given to the Technology and Health Unit (Unidad de Tecnología y Sanidad, or UTS) under the General Directorate of Productive Development (Dirección General de Desarrollo Productivo, or DGDP) in the Ministry of Agriculture (Ministerio de Asuntos Campesinos y Agropecuarios, or MACA), which today is known as the Ministry of Rural and Agricultural Development and Environment (Ministerio de Desarrollo Rural, Agropecuario y de Medio Ambiente, or MDRAyMA). This unit has been responsible for strategic orientation, the setting of priorities with regard to research and development on the national level, and the coordination of activities among various agents. Among other activities, UTS has developed regulations for funding facilities in consultation with stakeholders and has worked on linkages with international research and development agents.
- *Foundations for agricultural and forestry technology development (fundaciones para el desarrollo tecnológico agropecuario y forestal, FDTAs).* These four foundations, of semipublic character with a private status and a public mandate, promote agricultural innovation in the four agro-ecological regions: highlands, valleys, semiarid lowlands (the Chaco), and humid tropic lowlands. They receive funding for applied technological innovation projects from the central SIBTA funding facility. Each foundation has a board of directors and an autonomous administration headed by a managing director chosen by the board. Given their character of public interests but private management with a semi-independent status, the foundations have consistently pursued development goals, maintained financial integrity, and employed motivated staff on the basis of technical capacity. The FDTAs don't execute research and extension; they set regional priorities, interact as a broker with stakeholders in agricultural innovation, detect demands, channel funds, and bring agents together.
- *Donors.* The funding for SIBTA is provided through a basket fund to which the Bolivian government contributes through a loan from IADB. In the basket fund arrangement, the Common Fund for the Support of SIBTA (Fondo Común de Apoyo al SIBTA, or FOCAS), the governments of Switzerland, Holland, Great Britain, and Denmark contribute 50 percent, and three other donors—USAID, Germany (GTZ), and Japan—provide parallel funding geographically or thematically earmarked (USAID to the FDTA in the valleys region, GTZ to the FDTA in the Chaco region, and Japan to the Humid Tropics region. DFID provides additional funds for a project that accompanies SIBTA's efforts to improve its functioning and operation. The SIBTA budget for the 2002–2007 period is US$60 million, of which IADB provides around

50%, the basket donors provide $25 million, and other donors provide the rest. In the initial phase donors participated substantially in the design of the system, and in later stages they have pursued monitoring and evaluation in compliance with their internal accountability mechanisms. Representatives of the government and the donors are working together in the Advisory Committee of SIBTA (Comité de Acompañamiento del SIBTA, or CAS), discussing and defining procedures and guidelines for the functioning of the system.

- *Coordination Unit for the Agricultural Services Program (Unidad de Coordinación del Programa de Servicios Agropecuarios, or UCPSA).* Established in compliance with IADB procedures, this unit aids in the institutionalization of the system and ensures that funds are efficiently and correctly administered and attributed to projects in conformity with IADB regulations. Due to vacuums in the system and other reasons, UCPSA has filled roles ranging from normative policymaking to accompanying project management processes at the regional foundations. However, its mandate in these functions is not clear, and it has been suggested that UCPSA's role be reduced more strictly to auditing functions, leaving more space for decision making through UTS.
- *Claimants (demandantes).* Claimants are those producer organizations that request SIBTA's services; they usually end up being the users of SIBTA's services and the beneficiaries of its results. The system foresees that farmers and their organizations participate in formal bidding processes for applied technology projects organized by the FDTAs and hand in requests for technology transfer and technical assistance. Claimants can only be organized groups such as producer associations, community-based organizations, or indigenous groups with a legal status. Claimants are eligible for funding if they provide a counterpart of at least 15 percent of the total funding requested, either on their own or through third parties.
- *Technology and knowledge providers (los oferentes)*. Once the most relevant claimant requests have been identified, the FDTAs solicit bids from knowledge and technology providers, and credit funding to the most promising offers according to a criteria catalogue established in the SIBTA regulations. Providers of knowledge and technology include research organizations such as CIAT and PROINPA, university departments and centers, and many specialized private development and extension consultancy companies that have been created in past years in the absence of a state extension service.
- *Local and regional governments.* Municipalities have become engaged in applied technological innovation projects complementing the 15 percent of project costs claimants have to contribute. Departmental governments have participated on the boards of some FDTAs.

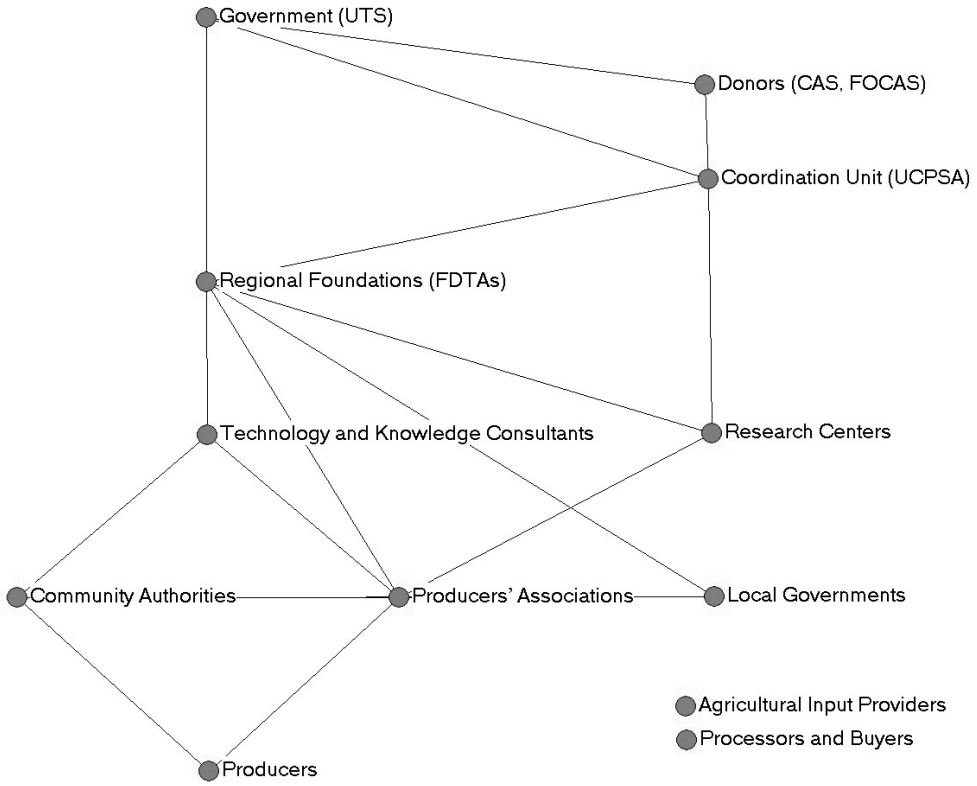
Some of SIBTA's applied technological innovation projects involve buyers, processors, or exporters as well as providers of agricultural inputs (e.g., machinery, seeds, fertilizers, agrochemicals). Although SIBTA bylaws do not explicitly foresee the inclusion of such agents, anecdotal evidence suggests that they have provided important information about technological innovations and market requirements and have even, in the frame of some projects, become linked to innovating farmers through contractual relationships.

Other agents that have played some role in agricultural innovation—not under SIBTA's umbrella but in its environment—are specialized government agencies such as the Agricultural Health Service (Servicio de Sanidad Agrícola y Ganadera, or SENASAG) and other government support programs that work in the areas of seeds, irrigation, and the environment. Some such agencies play important roles in applied technological innovation projects.

Although maintaining a high profile in rural development in Bolivia, only a few NGOs have become linked to SIBTA. Only those qualified as technology and knowledge providers can actually participate; however, quite a few are members of the foundations.

Figure 3 shows the various agents in SIBTA and their structural affiliation as intended in the initial design of SIBTA. The lines depict which agents interact but do not indicate hierarchies.

Figure 3. Relationships between SIBTA agents according to the original design



SIBTA has developed three main facilities that permit interactions among its various agents: applied technology projects, strategic innovation projects, and a mechanism to manage genetic resources:

- Applied technological innovation projects (proyectos de innovación technológica aplicada, or PITAs) are set up on the basis of farmers' organizations participating in formal bidding processes organized by the FDTAs. The FDTAs organize the bidding processes in the frame of agricultural production chains prioritized on the national and local levels. The organizations hand in requests for technology transfer and technical assistance. After a process of qualifying the requests, the FDTAs solicit bids from knowledge and technology providers, mostly research organizations and private consultancy companies that were established in the aftermath of the elimination of the public extension service, and credit funding to the most promising offers.
- Under the National Strategic Innovation Project facility (Proyectos de Innovación Estratégica Nacional, or PIENs) the DGDP in the government accredits funding for strategic research consortiums—for example, in the areas of soil fertility management or the development of agricultural commodity chains, such as in the peanut sector.
- The National System for the Management, Conservation, Use, and Evaluation of Genetic Resources (Sistema Nacional de Manejo, Conservación, Utilización y Evaluación de los Recursos Genéticos para la Agricultura y Alimentación, or SINARGEAA) was set up to carry out basic research and conserve genetic materials. Under this facility a number of research organizations and universities have been given the responsibility to manage and evaluate genetic resources in sectors such as roots and tubers, fruits, cereals and oilseeds, Andean grains, forestry, and camelids.

SIBTA's designers further envisioned that basic and strategic research will be carried out by international research institutes, such as the centers of the Consultative Group on International Agricultural Research (CGIAR), and other research institutes and universities abroad. UTS has tried to promote such linkages with the various local technology and knowledge providers.

Linkages among innovation agents, particularly claimants and knowledge and technology providers, have been induced efficiently through the funding facilities and lay in the hands of the foundations. Linkages to other actors outside the *demandante-oferente* relation of the PITA framework have not been encouraged. However, some foundations have at times promoted linkages to buyers and input providers to foster project success. The government agents have done little to mediate linkages on a national level: for example, few applied projects have been connected with strategic research, few applied projects have been connected to buyers and processors of agricultural and food products, and few links to universities have been established. The efforts to connect the system with international research organizations have also been less than successful.

The government has provided funding through the three funding facilities we have mentioned, and all of the funding has come with clear rules. Funding levels, although not sufficient to reach all potential innovators in rural areas, have nevertheless been substantial. Yet funding has not always come with sufficient incentives for agents to actively pursue innovation opportunities further to the project implementation phase.

The system's main rules of operation are provided by the regulations for the carrying out of the applied and strategic innovation projects. In addition, the regulations of the IADB loan contribute a set of rules to the system. The criteria for selecting PITA offers are strict and based on the regulations; compliance is administered by UCPSA. Other directives from UTS that do not come tied to the disbursement of funds have sometimes been overlooked by the foundations and other agents. A law for the operation of SIBTA has been drafted but never proceeded into the process of ratification. In addition, some general rules of conduct have been established—for example, it is customary to make decisions in CAS on the basis of consensus.

4.3 Problems and Challenges

SIBTA is a novel institutional arrangement, and as yet there is hardly sufficient information and experience available to know how to best run it. Its first years of operation have been marked not only by problems in establishing working procedures among agents but also by challenges related to structure and design:

1. The system's main technology transfer facility, the PITA, was designed in such a way that it responds to articulated farmers' demands. Yet such demands are difficult to detect among smallholders who are usually not well informed about market and technological opportunities and who express their needs commonly in forms other than those required by SIBTA's bidding processes. Furthermore, many farmers are not organized in associations, and that is the only way to become eligible to receive support. As a consequence, the FDTAs, and at times the *oferentes* as well, have had to undertake substantial work to first detect latent existing demands, encourage producers to hand in proposals, and help in developing proposals and the setting up of associations eligible to receive support. In fact, surveys show that SIBTA beneficiaries have rated the organizational development among the most important attributes of the PITA process (GTZ 2006). However, such services have not been remunerated through the system and hence remain informal and underdeveloped.
2. The basket funding mechanism and the bidding process for the PITAs (both claimants and technology providers hand in a proposal together) have come with substantial bureaucratic costs. Lema et al. (2006) argue that the transaction costs of SIBTA have decreased over time and now

are low in international comparison with other funding schemes. Yet it seems that at the level of the FDTAs, complying with SIBTA rules has taken up substantial time and resources, reducing the possibilities for strategic planning and monitoring of projects.

3. The system's success has been limited by the country's thin base of knowledge and technology providers and scarce professional capacities. The few research institutions are complemented by a number of small private consultancy companies and extension organizations that are supposed to form the so-called "network of technology providers" (*red de oferentes*). Yet most of those entities cannot count on access to all the relevant knowledge and are often limited in capacity. They also have become dependent on the PITA mechanisms. SIBTA regulations, however, do not allow them to cover their overhead costs of operation, which contributes to their institutional weakening.
4. Much of the knowledge and technology promoted by SIBTA agents is not formally evaluated with regard to its usefulness and conformity to farmers' conditions. Evaluation has been exercised through anonymous panels, but at times those panels have, due to lack of time and technical capacities, evaluated technology providers' proposals simply on the basis of formal criteria. Further improvement of the disseminated technology packages and adjustments to changing conditions has been left to the goodwill of technology providers and has not been subject to any incentives or evaluation criteria. In consequence many of the promoted technologies either have been suboptimal solutions or have not responded to local conditions and the absorptive capabilities of the beneficiaries.
5. SIBTA promotes collaboration between technology providers and users but it does not emphasize the integration of other innovation agents, such as buyers, processors, input providers, other government and development programs, NGOs, and others (e.g., see Gandarillas et al. 2007). This has led in cases to the isolation of the induced innovation processes and hindered broader networking and wider diffusion. The applied technological innovation projects have been too small in size and scope and insufficiently connected among themselves and with other agents in the system and respective value chains to be able to generate more radical innovations with wider adoption potentials.
6. SIBTA's design is rooted in an attempt to overcome shortcomings in systems that predominantly focus on research that then does not get applied. Given the scarcity of research capacity, the system has become biased toward technology transfer and extension, generating only few advances in knowledge and applied research results. However, regulations have not allowed for covering overhead, an important mechanism to guarantee the engagement and survival of

technology-providing agents, especially small technology transfer companies and consultant firms.

7. The system has also suffered from the limited availability of funds among private entities and farmers. The 15 percent co-financing rule, which is aimed at guaranteeing the farmers' ownership of the project, has at times corrupted the system because few claimants, especially poor farmers, have been able to get hold of the funds. For example, technology providers have passed funds to claimants so that they could pay their part; the technology provider, in turn, received the main share of the project funds for providing the services. In other cases, rather than the farmers' organizations providing the counterpart, it was paid by municipalities, who do not necessarily represent the farmers' interests.

These problems are well known, and as a consequence of many discussions and consultations, SIBTA's stakeholders, within the frame of the program's possibilities, have tried to apply a number of adjustments, such as, for example, revising the project regulations, building sector-wide strategic research programs, and strengthening capacities in different areas. The DFID-funded program for the Facilitation of Technological Innovation (FIT), in the framework of SIBTA, has studied options for improving the system—such as, for example, evaluating project impacts, using new information and communication technologies, strengthening producers' capacities to articulate their demands, strengthening capacities in the analysis of agricultural value chains, fostering the establishment of a market for technologies between technology providers and claimants, involving the private sector more prominently, and linking up with the centers of the CGIAR. As such the FIT program has acted as a participatory learning mechanism working toward improved systems performance of SIBTA.

SIBTA's overall performance should be seen in the context of distinct limitations, particularly with regard to Bolivia's capabilities in research and development, the level of development of the agricultural sector, the adoption capabilities of the farming community, the availability of complementary resources that are needed in the innovation process, and the weaknesses of various previous governments (Muñoz Elsner, Cruz, and Canedo 2005) as well as the limits in funding. An evaluation carried out in early 2006 (Lema et al. 2006) revealed that SIBTA has financed 264 PITAs (72 concluded, 151 in execution, and 41 to be initiated) in 165 municipalities of the country's nine departments, providing benefits to some 84,117 families. Adoption rates of the promoted technologies are estimated to be at around an average of 72.5 percent. Two hundred thirty claimants and 135 technology providers got involved in the applied technological innovation projects. At least 23 projects have addressed ethnic groups, all of which aim at strengthening the role of rural women. A recent client satisfaction survey of SIBTA's operations in the Chaco region (GTZ 2006) revealed satisfaction levels of 80 percent among SIBTA's beneficiaries.

By some estimates SIBTA has attended to some 23 percent of the rural communities and therefore needs an additional US$200 million to attend to all farmers (Lema et al. 2006). However, such estimations are of little value as they don't show to what degree farmers actually have gotten involved in innovation processes and how far their livelihoods have improved. Figures indicate that income increase has been around 88 percent. Anecdotal evidence suggests that some applied technology projects led to significant increases in income where others had only marginal impacts but strengthened farmers' capacities in general (Saín 2004).

The current rhetoric about the extent of SIBTA's impact on the rural poor and recent changes in the Bolivian government suggests applying radical changes to the design of SIBTA. Efforts are afoot to put the responsibility for generation of knowledge and technology predominantly in a National Institute for Agricultural Research (an INIA), to be newly created. From the side of the Ministry of Planning there are efforts to set up a Bolivian Innovation System (Sistema Boliviano de Innovación) of which SIBTA would become a part. As a consequence, government funding and regional development responsibilities may be moved away from the foundations.

5. ANALYZING SIBTA'S GOVERNANCE

In this section we discuss how SIBTA has been governed with regard to the five governance principles defined earlier and whether its governance has been conducive to its performance.

5.1 Participation

Bolivia is characterized by a large number and variety of farmers' organizations, committees, syndicates, unions, and associations, which are often linked to various political and other higher-level interest groups (Grootaert and Narayan 2001). SIBTA has invited farmers' organizations on the local level to articulate their demands and has made them the primary beneficiaries of the projects it funds. The farmers' organizations have participated in the articulation of demands, but in fact it has often been the knowledge-providing agencies that have steered the process of project development and submission to the FDTAs. Many interviewees actually mentioned that SIBTA should be opened up so that it is accessible to a larger variety of actors.

In planning and priority setting, the foundations do have the flexibility to involve stakeholders, and some farmers' organizations have been represented on the foundations' boards. However, second-level farmers' organizations such as farmers' unions and syndicates have not participated actively in the decision-making committees of SIBTA. Many interviewees were of the opinion that the foundations should invite more participation in their planning procedures, involving stakeholders in workshops and consultations that are open to a broader audience.

Besides the 15 percent counterpart in the project funding, which farmers' organizations often contribute in kind or via third-party donors, participation of farmers and their organizations as well as private-sector entities in the funding of SIBTA's activities has been marginal. Application procedures and existing participation schemes often discourage the participation of larger and medium-sized companies (Marr and Chancelor 2005). Smaller entities and farmers have likewise been discouraged by inadequate participation schemes within the projects, bureaucratic bidding processes, and simply the fact of not having sufficient resources. As a consequence, and this was articulated by a number of interviewees, the collaborative funding mechanism of the 15 percent counterpart has not empowered farmers as purchasers, providers, and co-financers of research and innovation activities. In this respect, some interviewees mentioned the need for regulatory reform in SIBTA to diversify funding sources (including those from the private sector) and disbursement mechanisms.

On the national level, donors to the common fund, FOCAS, and the Advisory Committee (Comité de Acompañamiento del Sistema, or CAS) have participated intensively in decisions on the design of the system and project implementation criteria. At times donor influence has been superior to that of the

government; lower-hierarchy government representatives do not have any decision-making power and higher-level government representatives are not motivated. Stakeholders from the farming communities and the private sector have participated in the Consultative Committee (Comité Consultivo del SIBTA), which has also seen the participation of representatives from UTS, the four regional foundations, agricultural colleges, and universities. The committee's function is to provide advice to decision makers in the government and the foundations and help in the coordination of SIBTA's activities. On the regional level local governments, producer associations, civil society, and the private sector have been members on the foundations' boards.

5.2 Transparency and Openness

SIBTA has achieved a high degree of transparency with regard to the use of funds. Yet regulations and bureaucratic procedures have sometimes stood in the way of achieving better transparency with regard to the decision making that leads to the attribution of funds, particularly in the boards of the foundations (Saín 2004). In addition, we find less transparency with regard to the results and impacts SIBTA generates, partly due to the absence of a baseline and monitoring and evaluation tools to compare situations before and after project interventions and partly due to problems in interpreting and comparing data on numbers of beneficiaries, adoption rates, and possible impacts. Various and at times repeating and redundant efforts were made to develop information databases, with mixed success. There are too many bureaucratic processes in collecting complex data, and there is no assurance of quality in the collection of data or that it is used in decision-making processes. Some interviewees mentioned that SIBTA may profit from more spaces for exchange of information and experiences among the diverse stakeholders so as to generate feedback from the projects and joint learning among more and less advanced knowledge providers and users.

5.3 Responsiveness and Accountability

SIBTA is oriented largely to respond to farmers' demands, which has led eventually to reduced proactiveness in problem solving and creativity in research. Responsiveness has been articulated on the level of the foundations, which maintain direct contacts with farmers' groups and other local agents. Responsiveness has been less articulated in the higher government ranks in UTS and UCPSA, which act as normative decision makers with a public mandate and hence respond only to the government and not to the wider stakeholder community. The established accountability mechanisms through the donors have been sufficient, although a more active role by the government in accountability issues may have been beneficial. Once funding is approved, service providers run projects according to plan and minimize their efforts and inputs. Some interviewees mentioned that the government and the FDTAs should put greater

effort into ensuring that knowledge providers are more accountable to clients and funding agents with regard to their outputs and products and services they deliver. Others argued that SIBTA must establish realistic, clearly understood performance measures for the evaluation of staff performance and knowledge providers; staff would need training in this area. Finally neither the foundations nor UTS or UCPSA have used monitoring and evaluation tools to analyze whether projects are on promising impact pathways and have not oriented the optimal use of funds and pursuit of innovation options. For example, evaluations were rarely done to see whether technology packages were improved during a project and adapted to new conditions.

5.4 Consensus Orientation and Coherence

The decision making in all SIBTA committees and boards has been participatory and based on consensus; however, the SIBTA regulations set up by donors and UCPSA have often played a more important role than the opinions of committee members, particularly with regard to how and where to attribute funds. Reaching consensus on the main priority areas of funding has been difficult for the foundations' boards. On the national level, priorities for the agrichains and sectors to be developed through SIBTA have been established following a rigid methodology. However, system-wide consensus on these priorities has not included all stakeholders and opinions on whether there are too few or too many priority areas in SIBTA and on which ones are the right ones still diverged greatly from interviewee to interviewee.

Difficulties also exist between the priorities set on the national level and on the regional level. With regard to coherence one finds that various PITAs in specific areas have been encouraged to collaborate and PIENs were supposed to give overall strategic research umbrellas to certain priority areas. However, government units had difficulties delegating responsibilities to the lower hierarchies. For example, UTS set national priorities for R&D topics and value chains and was at times reluctant to accept the prioritization of subsectors by the foundations on the regional level. UCPSA encountered difficulties delegating financial administration responsibilities to the administrative departments of the foundations. This meant both entities were charged with too many activities, impeding their involvement in issues of wider strategic importance.

Difficulties have also existed in the coordination and harmonization of planning and activities with other entities such as universities and donor programs. In fact SIBTA's institutional setting has not supported the formation of partnerships that would enable more coherent joint research agendas. Interviewees explained that without institutional and legal reform greater coherence and synergy between the different government and other development programs will be difficult to achieve.

5.5 Strategic Vision

Given the little support it received from higher government hierarchies, UTS may have lacked the capacity and data to conduct relatively sophisticated and accurate analyses of policies and areas of priorities. Instead, as mentioned above, it has been involved in lower-level decision making that could have been delegated or dealt with via clearer regulation setting. In addition, much of UTS's resources have been used to maintain national dialogues that have not always led to concrete policies and decisions. It is too soon to judge the experiences of the National Strategic Innovation Projects (PIENs) for which the UTS signed responsibility, but evidence does suggest that more strategic research and linkages with other innovation agents will be required to lead to broad-based innovation. In fact, a farmers' organization representative articulated the wish that a revised SIBTA would clarify (change) its mission and vision statements and establish a clearer role for the participation of various stakeholders' organizations, including farmers' organizations, funding sources, technology transfer agents, buyers, processors, input providers, other government and development programs, NGOs, and others.

5.6 Overall Governance Performance

SIBTA provides implicitly for a number of governance hierarchies: supervision and coordination functions are attributed to UTS in the Ministry of Agriculture; program activities, communication on the local level, and funding are to be carried out by the regional foundations; and accountability functions lie with UCPSA. Advisory and monitoring functions are attributed to the Advisory Committee of SIBTA (CAS). Yet such attribution of roles and functions to only one agent is not very feasible in a wide and participatory system of diverse actors; in fact one finds multiple actors involved in the various functions following the necessity of consultation and interaction. To demonstrate this diversity we have drawn a map of the actual multiple roles and relationships of SIBTA's agents.

Figure 4 results from the mapping of the relational data collected from interviews with key actors asking for the strength of ties with regard to priorities and normative functions of their agents. Some nodes represent specific agents, such as UTS, UCPSA, or CAS, others represent averages for certain types of agents, such as the foundations, farmers' associations, or local governments. The arrows show who proposes and communicates priorities and who is affected by that. A node's size is proportional to the importance of incoming links with regard to priority setting—that is, the amount of priority-setting advice the agency receives. A distinction has been made between the producers and their associations, assuming that it is the producers who direct the priorities of their association. However, given the weakness of many associations (which sometimes were created only for the purpose of a PITA), the communication of farmers directly has at times been stronger than that of their associations. The strength of the line depicts how strong the relationship is.

Figure 4 shows clearly that the regional foundations are at the center of the priority-setting process, receiving directives from all sides, most strongly from the producers. They communicate these priorities to the providers of knowledge and technology, such as research centers and private consultants.

Figure 4. Priority-setting relationships among SIBTA agents

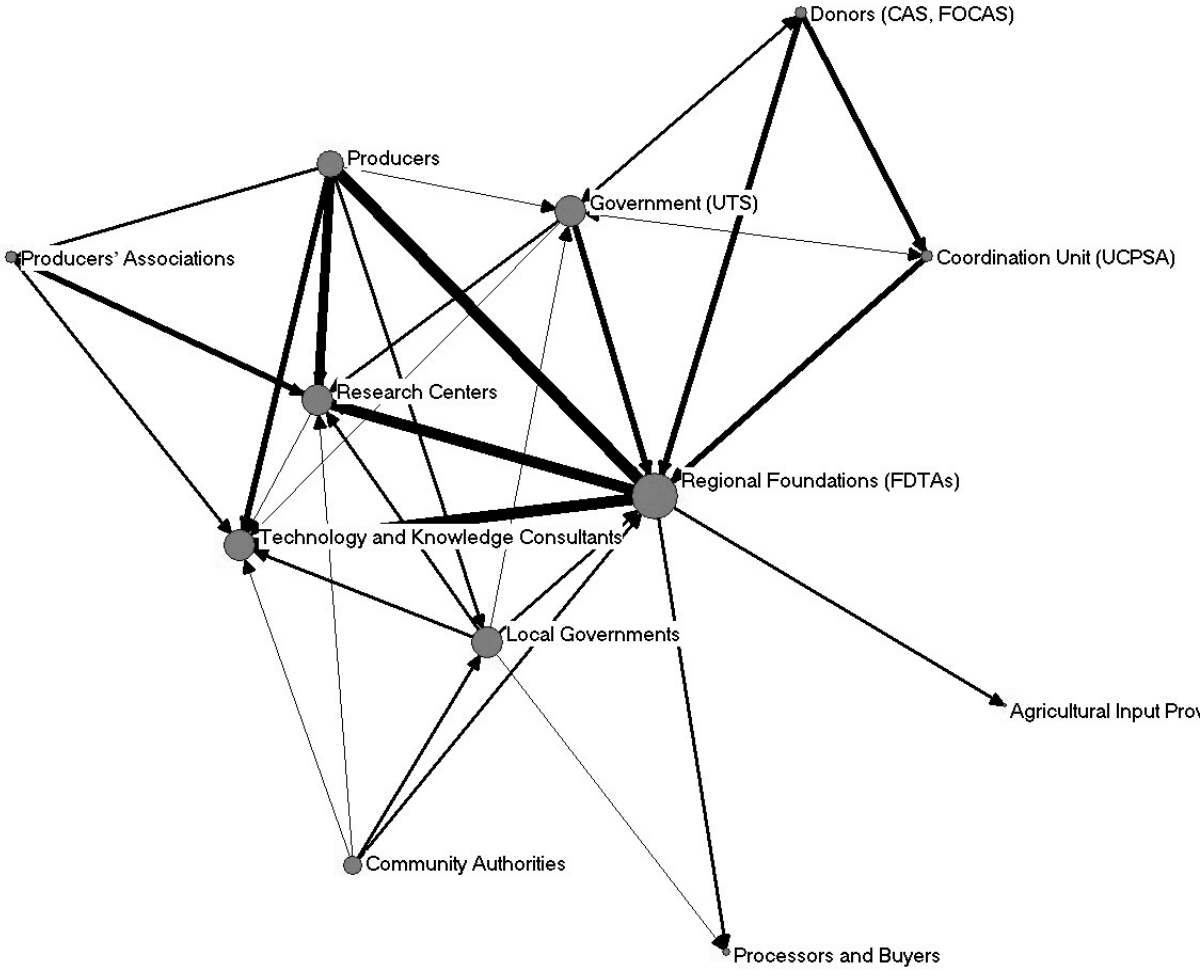
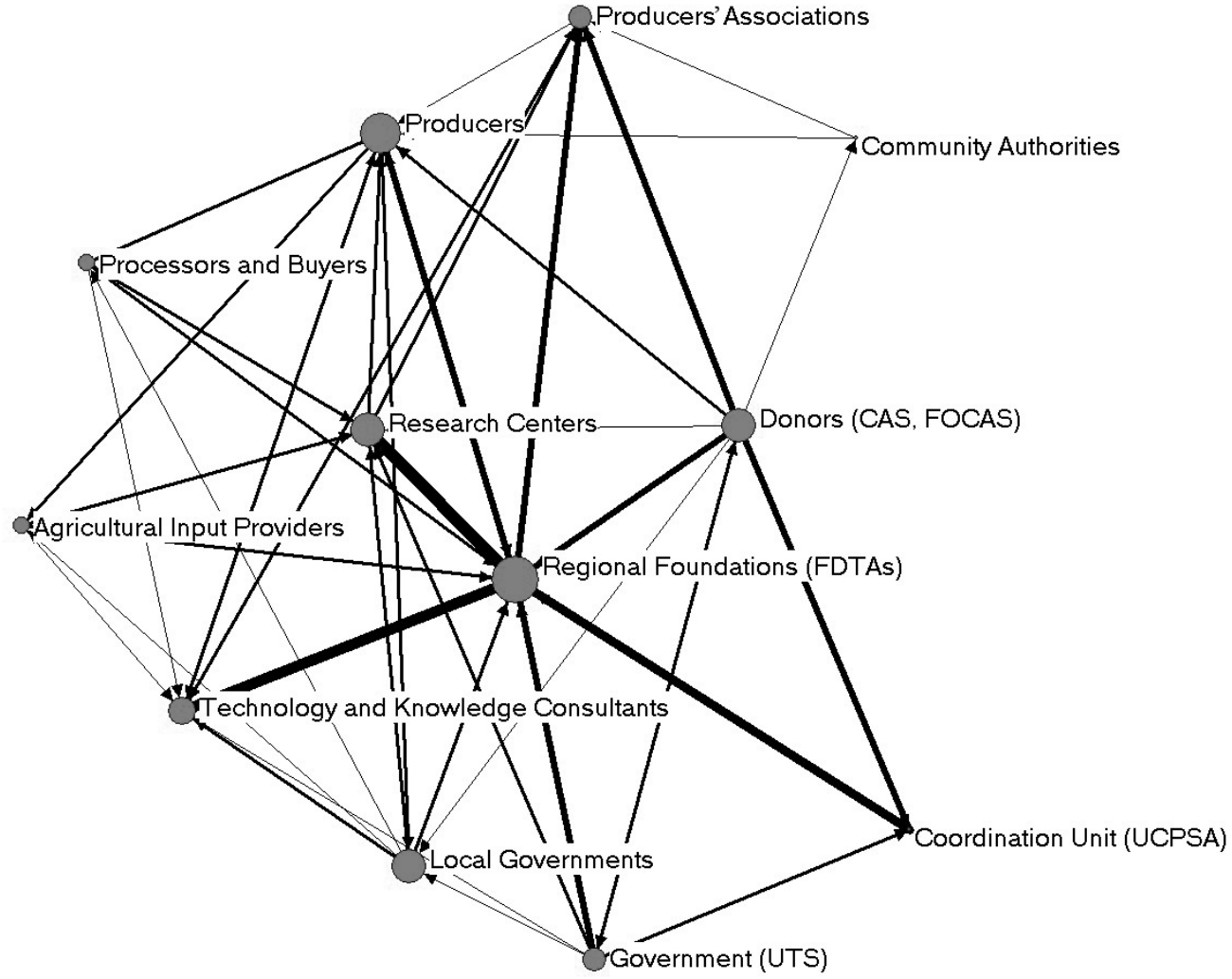


Figure 5 depicts relations among actors with regard to the flow of funds. The arrows depict who provides funding to whom or who makes decisions that determine other agents' access to funds. Node size is proportional to the receipt of funds. The boldness of the line depicts how strong the relationship is. Again it appears that the regional foundations occupy the center of relationships concerning funding decisions. They receive funds and channel them to the main recipients—research centers and local consultants. Producers and their associations appear less as counterparts but as recipients of funding. Processors, buyers, and input providers (commercial agents that are often in need of innovations to run their businesses) fund research and development, but directly and not through the foundations.

Figure 5. Funding relationships among SIBTA agents



In conclusion, system design often comes with some preconceptions about who should get involved in decision processes on the various levels. However, the two relational networks shown in the figures suggest that the roles and functions agents actually take, and how they interact, depend on other factors—the most prominent of which are funding regulations and an agent's motivation depending on incentives.

6. DISCUSSION

We now consider the value of the countries' experiences governing their agricultural innovation systems for the possible design and governance of the Bolivian agricultural innovation system. For that purpose we place the governance principles in a synopsis (Table 4) comparing Bolivia's approach with other "good practices"—a procedure that will help to discuss the study's research questions.

Table 4. Comparison of principles of agricultural innovation systems governance

Governance principle	***Situation in other countries***	***Situation with respect to SIBTA***
Participation	Nicaragua has many providers of knowledge and technologies, among them the public INTA, university institutes, NGOs, and projects of the development cooperation. Transparent and diverse mechanisms of funding permit most to participate in the innovation system.	The system's main technology transfer facility, the PITAs, are designed to respond to demands. Due to the regulations, only research centers, consultancy companies, and at times associations have been able to provide the requested technology transfer services; universities, NGOs, and other government programs have been excluded. The PITAs put researchers and technicians in contact with farmers for the purpose of knowledge transfer but do not provide for further collaboration with other agents in development or the private sector.
Transparency and openness	The Uruguayan INIA achieves transparency through its policy of open information on activities, numerous memoranda of understanding, and clear rules for co-financing. INIA leads the system but enables additional knowledge and technology providers.	SIBTA has not been transparent with regard to the results and impacts it generates, partly due to deficiencies in the interpretation of data on numbers of beneficiaries, adoption rates, and possible impacts and partly due to the lack of diffusion mechanisms and capacities to process such information among stakeholders. The Planning, Follow up, and Evaluation System (SIPSyE) constitutes a first step in the creation of a shared platform to handle information related to project/program implementation and available to the actors involved.
Responsiveness and accountability	In Senegal substantial efforts have been made to articulate and promote the demand for technological solutions on behalf of poor farmers so as to orient the unfocused research institutes toward farmers' needs. This together with two funding mechanisms for contracted research has made the system responsive to farmers' needs.	SIBTA responds to small farmers' needs but cannot reach all given its limited size. The mechanisms used to identify farmers' needs are deficient—some farmers cannot articulate their needs in the form of eligible demands and therefore require assistance from foundations and technology providers, opening up possibilities of fraud and abuse. Measures of accountability to donors may be sufficient, but accountability to other stakeholders, particularly small producers and their organizations, is not.

Table 4. Continued

Governance principle	*Situation in other countries*	*Situation with respect to SIBTA*
Consensus orientation and coherence	Sri Lanka has a rich institutional landscape of research departments/institutions with the capacity of contributing to the agricultural development of small farmers and the whole sector. Yet the system lacks coordination of priorities and funding, hindering collaboration and joint efforts in research and innovation. Recent efforts to address this problem are in the direction of the application of an innovation systems framework.	SIBTA suffers from weak capacity in the various knowledge and technology providers (*oferentes*) it involves. The few projects conducted are not linked with other projects, missing out on the opportunity to provide feedback to other potential technology generators. No coherent programs exist that provide strategic guidance and joint learning among different projects and agents involved.
Strategic vision	In Thailand an autonomous National Innovation Agency promotes collective actions among various agents in the national innovation system. It brings producers together with actors that can provide knowledge and technology, finance, and access to markets. NIA also develops visionary strategies based on market conditions and technological opportunities that do not only reflect short-term producer interests.	SIBTA may have too many prioritized development themes and commodities. It lacks focus and a long-term strategic vision, and falls short of having mechanisms that identify technological and market opportunities that are not based on short-term stakeholder interests.

The comparison allows us to discuss the three research questions set forth in section 2. Regarding the first question—What main parameters have characterized the agent constellations in Bolivia's agricultural innovation system regarding the roles agents take and the power they exercise?—it appears that the original system design and regulations are not the only, and perhaps not even the main, parameters shaping the agent constellations. The original design put major emphasis on the four regional foundations, and they do play a crucial role in identifying priorities and receiving demands. However, in funding they seem to be less important, as they simply apply regulations and channel the funds they receive. They are hardly involved in the innovation processes or networking for the development of innovations. Other systems, such as in Uruguay and Thailand, deploy much more efficient central organizations that actually allow for collecting experiences and learning in the various projects and organizations and processing this information and developing new knowledge and technology on this basis via a central research institution (case of Uruguay) or delegating the task to various institutions through a central planning unit in the government (case of Thailand). However, some foundations, especially the Fundación Valles, through intensive donor support (not within the mode of the common fund) have been able to develop substantial capacities of research planning and effective mechanisms of knowledge exchange. Constellations have been rather established through the work strength of the different agents, their motivation, and, in cases where some agents were weak, the capacity of filling power vacuums, as seen in the case of the administrative unit UCPSA, which took over roles of the weak planning unit, UTS.

Regarding the second question—How do policymakers ensure the coordination and delegation of interaction and how do stakeholders participate in the priority-setting and funding activities and the actual carrying out of projects and programs that foster innovation?—the information on SIBTA reveals that little actual delegation from the central government units to the foundations has been taking place. In fact, both UCPSA and UTS have focused too much on micro-level administration and management, neglecting the development of broader strategies and evaluation of overall efficiency. Delegation of research and advisory service functions was left entirely to the contracted knowledge providers, which led to the problem of no coordination or exchange of innovation activities and their results. Nonetheless, the Senegal case demonstrates that the management committee can provide a strategic vision for innovation. Government representatives hold one-quarter of the seats in the committee and the remaining places are for representatives of the research community, producer organizations, agro-processors, export and import industries, decentralized collectives, NGOs, and extension services—which provides a different dynamic to the system. For transparency and independence, the executive secretariat is selected through a competitive process by an independent firm.

With regard to the third question—How is the innovation system organized spatially? Are local, regional, and national agents and priorities sufficiently reflected?—SIBTA reflects a mix between central government bodies, regional foundations, and the carrying out of innovation support on the local community level via the PITAs. Each PITA reflects local demands and tries to connect such demands with technological solutions provided by local agents that also have access to national and international sources of information. Yet regional and national priorities are developed in a process that bypasses the demands to which the PITAs respond, leading at times to a lack of coherence. It seems that other SIBTA research facilities, like the PIENs (proyectos de investigación estratégica nacional), did not consider problems identified through PITAs on the local level; this indicates a lack of feedback. In general more support in terms of alternative practices and technologies would have benefited the PITAs, particularly because the technical coherence of the knowledge offered by the technology providers was usually not evaluated. The dynamics of innovation usually require the flavoring of local knowledge with other local and international knowledge, intensive discussion and trial among local and external agents, and the interweaving of demand pull and technology push mechanisms; the PITAs fell short in providing this sort of interaction. In countries such as Senegal, where beneficiaries find it difficult to articulate their demands vis-à-vis public research institutes, efforts to strengthen their capacities have resulted in strengthening the demand pull factors. Coordination on the national and regional levels as set forth in the new Sri Lankan Agricultural Innovation System may indicate ways to better harmonize these levels of spatial innovation planning.

7. CONCLUSIONS AND RECOMMENDATIONS

Given the increasing competition worldwide and the challenges in production, natural resource management, and poverty alleviation, recently many developing countries have undertaken increased efforts to understand and strengthen their national innovation systems. Such efforts must take into account the changes such systems are often subject to. Bolivia, for example, has used different institutional settings to foster modernization and innovation in agriculture and rural areas, moving away from separate research and extension programs under the umbrella of a central government to the decentralized semipublic setting of the Bolivian System of Agricultural Technology (SIBTA), in which government support of agricultural research and extension is partly delegated to regional semiautonomous foundations, each responsible for one of Bolivia's main agro-ecological regions (highlands, valleys, tropical semiarid region [the Chaco], and humid tropics). Following the idea of a market for knowledge and technology, in SIBTA's institutional setting small producers are expected to request technical assistance. In response to producers' demands, providers of agricultural knowledge and technology—mostly private research and consulting agencies and nongovernmental organizations—develop applied research and technology transfer projects funded through the regional foundations. Central government units in the Ministry of Agriculture are responsible for setting funding priorities and rules.

This report focuses on successes and failures in innovation systems governance and policymaking in the context of SIBTA, and it derives conclusions regarding principles and opportunities for improving the governance of agricultural innovation systems in developing countries in general. In light of the need to foster agricultural innovation in many developing countries, the challenge is to determine how governments can best approach and adjust their agricultural innovation systems and govern the different entities and agents for maximum alignment with development priorities and the demands of beneficiaries, especially the rural poor, taking into account the dynamics of local innovation processes.

Our review of theoretical concepts related to innovation and governance in the context of developing countries and agricultural and rural development suggests that traditional approaches to innovation based on supply-driven or demand-and-market-driven concepts and simple market failure arguments fail to take into account the real complexity of the innovation process. Innovation requires the interaction of multiple agents, and any effort to govern a system composed of those agents needs to take into account the limitations that any policymaking body has in dictating how agents behave and interact. Governance in innovation systems has less to do with executing research and administering extension services and more to do with guiding diverse actors involved in complex innovation processes through the rules and incentives that foster the creation, application, and diffusion of knowledge and technologies. The role the government plays in fostering agricultural innovation depends on institutional regulations;

the strengths, weaknesses, and motivations of the actors that contribute to innovation; and the style of governance.

The study analyzed to what extent the Bolivian System of Agricultural Technology (SIBTA), as part of Bolivia's agricultural innovation system, has complied with important principles of governance—participation, transparency, accountability, coherence, and strategic vision—and compared those parameters with good practices in innovation systems governance in other developing countries. A number of general conclusions with relevance to innovation systems governance in developing countries are drawn from this analysis:

- SIBTA, as well as many other government structures and programs in developing countries, constitutes a decentralized funding and priority-setting mechanism. As such, it constitutes only a part of what the literature calls an innovation system. This implies that besides the existing focus on research and extension, other important complementary functions may exist with which the government must comply—for example, functions related to (1) the strengthening of innovation agents, including small producers and processors; (2) the strengthening of research and extension agents; (3) the mediation of interactions among various agents; and (4) the provision of important complementary infrastructure and inputs in innovation processes (e.g., credits, rural roads, irrigation systems, etc.). Some of these functions fall outside the boundaries of research and technology transfer systems such as SIBTA, but they must be considered complementary if one wishes to boost agricultural innovation. The Bolivian government, for example, instead of aiming at carrying out research and extension, should rather focus on overall planning and bringing the above functions together so that they reach the innovating agents. This would involve planning and policy analysis, the setting of consultation platforms, support for the building of innovation networks, and the setup of specific funding mechanisms.
- The decentralization of decisions on the allocation of funds—such as performed in the case of SIBTA's regional foundations—does not automatically lead to more participation of local producer organizations and technology providers that are usually required to steer successful innovation processes. In fact, SIBTA's regulations have effectively excluded many actors that could not comply with the acquisition criteria, including buyers, input providers, NGOs, and others. Improved participation requires the provision of more rules and incentives to foster collaboration among multiple agents and eventually further decentralization on the regional level.
- The setting up of decentralized priority-setting and funding structures, such as the regional foundations, can lead to the questioning of authority and competence and eventually weaken the government's central planning function and impede the development of a national strategic vision through the state. However, weak leadership and limited commitment—rather than the

decentralized structural setting and delegation of too much power—have prevented the Bolivian government, particularly the Ministry of Agriculture, from taking a more active role in steering SIBTA. One wonders whether the lack of interest the government has shown in SIBTA is related to the institutional limitations on manipulations or excessive donor influence. In any case, decentralization need not stand in the way of a national strategic vision, and mechanisms need to be put in place to discuss and harmonize the priorities on the national and local levels. The Bolivian government, for example, instead of aiming at micromanaging the regional foundations should rather focus on the big picture and conduct policy analysis and strategic planning to identify opportunities for agricultural innovation.

- Being responsive and reacting to farmers' demands does not necessarily imply that the best technological solutions are generated. Generating adequate innovations requires the participation of many: leading and other producers, knowledge and technology providers, but also buyers, input sellers, funding agencies, advisory services, and others. Farmers' demands come in various forms—at times they are concrete and relate to real opportunities but more often they come as a confused request for help in production. In any case, ample space exists to analyze opportunities, which in consequence can lead to either the formation of demands that farmers were not aware of or the disqualification of a demand as not substantially contributing to the needs of the claimant. The Bolivian government, for example, instead of involving itself too much in the rhetoric on genuine farmers' demands and responding ad hoc to the rightful claim of only a limited number of interest groups should rather foster in-depth analysis of farmers' demands on the local level through decentralized organizations that simultaneously help to orient such demands to where technological and market opportunities lie. This requires improved analytical and planning capacities as well as intensive communication with farmers and agents that dispose of new and promising technologies.

A number of conclusions that specifically relate to the Bolivian context and SIBTA are also drawn:

- SIBTA is not yet sufficiently accountable to clients, although it might be to funding agencies. Participation of innovator groups in governance bodies, co-financing where possible, and participatory evaluation are central to ensuring accountability. The necessary structures and skills among SIBTA officials must still be created.
- Involvement of the central government has been at times weak, leading to inadequate leadership, inadequate policy formulation, and inadequate macro-level priority setting. The vacuum has led to other agents, such as donors and administrative bodies, exercising leadership that is not in their

mandate. Donor influence has led to bureaucracy and orientation to compliance with regulations. Administrative issues therefore have become at times more important than technical issues.

- Policymakers have ensured coordination and delegation of innovation tasks to a certain extent. At times, instead of orientation toward broad strategic policymaking, due to a lack of analytical capacity and data, policymakers have fallen back on bureaucratic processes and participatory priority setting, leading to too many dispersed priorities.
- The spatial organization of the system reflects priorities and demands of producers on the local, regional, and national levels. Local demands have been reflected particularly where the regional foundations have set up local offices. On the regional level, the foundations have made sure that demands from various localities enter the competition for project funding. Coherent development of regional and national priorities has been left to processes besides the local demands articulated in PITAs and has been based on limited stakeholder consultations and analysis of secondary data.

Our analysis also leads to a number of concrete recommendations that in the future could improve the governance of both SIBTA and the agricultural innovation system as a whole:

- *Participation.* SIBTA provides an opportunity for farmer participation through the farmers articulating their demands in response to calls for proposals and through the inclusion of farmers' associations on the regional foundation boards. However, it has not provided much space for real participation in priority setting and research and development. Real participation in innovation processes requires the involvement of diverse actors in network-like structures that provide access to knowledge, technologies, learning grounds, credit, markets, funding, inputs, and other ingredients, all simultaneously. Organizational development and capacity strengthening can help to improve the quality of the demands that farmers articulate.
- *Transparency and openness.* SIBTA has achieved a high degree of transparency with regard to the use of funds, but it has not promoted the creation of spaces for exchange of information and experiences among the diverse stakeholders of the Bolivian agricultural innovation system. Creating and organizing discussion forums on specific innovation issues and organizing interregional (departmental) meetings have been found to be good practices that should be replicated in the future to achieve greater transparency and openness in the development of innovations.
- *Responsiveness and accountability.* SIBTA is responsive to farmers' demands but does not do enough to analyze those demands and match them with technological and market opportunities. Regarding evaluation of adoptions, technology providers and research institutes need to conduct more critical evaluations of the appropriateness of the knowledge they promote, proving that it is state of the art and contributing substantially to increase benefits of small farmers.

- *Coordination and coherence.* Innovation system policies need to ensure that SIBTA opens itself to the academic and the productive sectors. SIBTA still needs to develop mechanisms to strengthen research capacities so as to be able contribute to innovation in a more profound way. Researchers, along with their research results, need to be involved in local innovation networks. Funding mechanisms need to be able to target partnerships and collaborations among diverse actors such as producers, processors, buyers, universities, development programs, NGOs, and others. It is also necessary to set up a central policy analysis unit to provide general guidelines and suggest priorities on the basis of data analysis. Also required are local and/or regional units to analyze concrete development demands and opportunities and to communicate and exchange knowledge with other local units. Bolivia should not view science and technology as a component apart from innovation but rather as a component that necessarily needs to become imbedded in innovation dynamics. This requires technical convergence across different sectors and complementarity between different policy instruments under different ministerial mandates. To address this, Bolivian policy actors at both operational and strategic levels need to understand their sectoral responsibilities in a wider context so that they can make the most of science, technology, and innovation.
- *Strategic vision.* Incoherent priorities and funding rules on the local, regional, and national levels reflect the lack of an overall vision on how SIBTA shall support agricultural innovation processes that benefit the poor. A thorough analysis of technological development opportunities may help in clarifying the path that efforts toward agricultural innovation in Bolivia should follow. This would also require defining how to include other providers of knowledge and technology that have not yet been able to link with SIBTA's innovation efforts. A central policy analysis unit—including a team bringing in ample experience in evaluating past developments and future opportunities as well as in innovation policy analysis—would be able to fill this gap.

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