"Concepts, Policy Elements, and Regional Strategies for the Development of Institutional Innovation"

Forum for the Americas on Agricultural Research and Technology Development

"Concepts, Policy Elements, and Regional Strategies for the Development of Institutional Innovation"

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Summary

The document presents the findings of a study of the trends and challenges in agricultural research in Latin America and the Caribbean (LAC), in terms of the way it is organized and its institutional architecture. The study was carried out for the Forum of the Americas on Agricultural Research and Technology Development (FORAGRO)[1], with support from the Global Forum on Agricultural Research (GFAR). The subject of the study is also one of IICA's Strategic Priorities, established in its 2006-2010 Medium Term Plan (*Promoting the Introduction of Technology and Innovation for the Modernization of Agriculture and Rural Development*). The general objective of this priority is to support the efforts of the member countries to modernize agriculture and enhance its contribution to economic, social and environmental development by promoting technological and institutional innovation policies and processes that will promote and facilitate the incorporation of new knowledge and technologies into agricultural production chains.

The study provides the bases for developing a conceptual framework for institutional innovations, with recommendations for a cooperation agenda aimed at revamping the institutional architecture of national and regional agricultural research. To that end, the study outlines the institutional innovations needed to strengthen the national and regional systems of agricultural science, technology and innovation in the region.

The study is divided into four sections, each of which addresses specific issues and objectives. The first section describes the transformations taking place in the global and regional contexts that have impacted the focus of research and its institutional framework in the agricultural sector. The second section presents the theoretical frame of reference, conceptual definitions and organization of the current institutional architecture for research and innovation in LAC. The third section focuses on the institutional innovations that some countries have implemented in their agricultural research systems. The fourth section offers some guidelines for developing a cooperation agenda related to institutional innovations for research in agriculture.

The first section deals with the many global transformations taking place that are also bringing about changes in the agricultural sector. The study notes that determining exactly what impact those global changes will have on the future direction of agriculture is quite a complex task. One of the reasons for this is that the economic, political, social, environmental and technological dimensions of the trends must be taken into account in order to understand their evolution.

The impact of the different global transformations is reflected in the way that agriculture is viewed. Having traditionally been a primary sector, it is evolving into an agribusiness industry, becoming more integrated with other sectors and economically more important in the process. The expansion of agribusiness activities is becoming

[1] http://www.iica.int/foragro

increasingly dependent on the capacity to innovate and develop new products and services, with S, T&I playing a key role.

In addressing the changes taking place in LAC agriculture and agricultural research systems and their institutional framework, the study takes into account two of the main factors involved:

- First, a new technological paradigm is being developed at the international level that affects the recognized conditions of competitiveness of agriculture. However, most Latin American and Caribbean countries are drifting away from the frontier of knowledge and failing to invest enough resources to bring themselves back to it;
- Second, cooperation on innovation is a key element for those who wish to play a leading role in agricultural development. Many technology-related cooperation experiences in LAC have had a big impact but they are fragmented and not geared toward either technological or institutional innovation.

The developing countries are faced with a variety of problems as far as agricultural innovation is concerned. One of the biggest is the structure of research, which suffers from a large number of weaknesses in critical areas (technological gaps, infrastructure, the organizational model, technical and administrative capabilities, etc.) that have had a negative impact on the progress of research. In conclusion, technological innovation efforts must go hand in hand with **organizational and institutional innovations**. Promoting innovation entails much more than promoting technology research and development.

A number of countries in different parts of the world have implemented institutional innovations in their agricultural research systems. Studies like the one by Jansen (2002) show the diverse nature of the initiatives implemented and the scope of the changes that have taken place. Those changes have had a major impact on the governability, financing and organization and execution of research in industrialized countries.

The LAC countries have also introduced institutional innovations, but mostly at the micro-institutional level (i.e., they have modernized the management of research organizations). Two conclusions can be drawn from the organizational changes instituted in LAC: i) micro-institutional changes are important but clearly insufficient to make institutions sustainable or LAC agribusinesses significantly more competitive; and, ii) the failure to introduce meso- and macro-level institutional innovations is bound to make agriculture less competitive, due to two simultaneous effects: a) institutions will drift away from the frontier of knowledge (and, as a result, be incapable of playing a leading role); and, b) it will become increasingly difficult to tap economic and technological opportunities.

The LAC region needs to overcome its limitations with respect to the most developed countries by implementing technological and institutional innovations at the meso- and macro-institutional levels. The study highlights the fact that institutions dedicated to agricultural research and innovation need to become more effective and efficient, and develop the components of an agenda for institutional innovation in the region.

The second section deals with the theoretical framework, based on the neo-institutionalist and neo-Schumpeterian literature. Concepts and analytical instruments were defined to present institutional innovations by their level of aggregation and degree of transformation, in order to generate data about the use and value of assets, and cooperation and the development of technologies better suited to the technical-economic and productive dynamic of the region.

In constructing a conceptual and interpretive approach to institutional innovations in agriculture, two key questions must be answered: 1) *What role do institutions play in generating and disseminating innovations?* And, 2) *How is institutional innovation defined in the innovation systems and networks?* Taking these questions as the starting point for the analysis, it became clear that institutional innovations in national and regional organizations, networks and systems dedicated to agricultural innovation are the result of a broad, complex array of actions, such as changes of management within the institutions, the introduction of new key players, and mechanisms, frameworks and institutional solutions that affect the integration, regulation, governability and coordination of systems. Thus, institutional changes in the systems and networks bring about changes in the organization and practice of scientific and technological research.

Adopting this approach, the section presents the results of a general mapping of the institutional framework for research and innovation in Latin America and the Caribbean. Also examined is the specific literature on the subject, incorporating and systematizing concepts and contributions made by authors such as Piñeiro et al. (1999), Ardila (1997 and 1999), Moscardi (2001), Chaparro (2001), Janssen (2000 and 2002), and Martinez Nogueira (2003), Salles-Filho et al. (1998 and 2001) and official documents of the IDB, IICA, ISNAR, GFAR, CGIAR, FORAGRO and FONTAGRO.

The third section outlines the institutional innovations implemented in LAC. Three cases were singled out for deeper analysis on account of their importance. In the area of innovation networks and projects, the study focused on the Network for Technological Innovation and Prospection for Agribusiness (RIPA), in Brazil, mainly because it involves different actors and segments in efforts to meet research needs. In the field of regional cooperation, the document examines the PROCI programs, created in the 1980s with support from IICA and the IDB. These programs have grown, incorporating a wide variety of topics, and have implemented initiatives to promote information sharing and the creation of partnerships. With regard to hemispheric cooperation for institutional innovation in research institutes, the study looked at Embrapa's Labex, or Virtual Laboratory Abroad. This initiative aims to expand and strengthen scientific and technological cooperation between Brazilian and foreign researchers.

The fourth section presents the study's conclusions. The analysis of the current direction of agricultural research in LAC suggests that national and regional networks play a strategic role in consolidating cooperation and encouraging agricultural research organizations to introduce institutional changes and innovations. In this regard, the

study concludes that cooperative work is one of the most effective ways of achieving three key objectives in this process: i) it reduces inefficiency (by limiting the amount of redundant and overlapping work undertaken); ii) it promotes opportunities due to the synergic effect of economies of scale and scope; and, iii) it reduces the uncertainty surrounding the adoption of knowledge (a technology, a service, a practice etc.). Thus, cooperation has a number of positive effects. Firstly, redundant efforts and sterile conflicts (which are unnecessary for the progress of knowledge) are eliminated or reduced. Secondly, more effective advantage can be taken of the effects of network economies. And, thirdly, the actors involved in the innovation process come together from the outset, thereby avoiding the classic dichotomy between the supply of, and demand for, knowledge that traditionally has created a gap between research and innovation.

Finally, the study suggests that effective cooperation on S&T and Innovation in LAC agriculture is possible even with very limited financial resources. It advocates using the funds available as seed money, to leverage more resources for generating S&T and Innovation that will have a major impact. It is time to do more than simply transfer information between countries and institutions, bearing in mind four important points:

a) The first concerns the need to increase the potential for cooperation. The cooperation model should not be limited to typical agricultural research institutions (especially the NARIs), particularly because it is they, along with IICA and the IDB, who provide financial resources for cooperation in agricultural R&D in LAC. On the contrary, the model should be multi-institutional and multi-national. It follows from this that: i) the initiatives should give strong consideration to the involvement of other types of institutions, even other areas of knowledge; and, ii) the initiatives should seek cooperation from institutions outside the region.

b) The second point has to do with the social appropriation of knowledge via innovation (technological and organizational innovation, new services, etc.). The cooperation model should adopt the "S&T + Innovation" approach (the model known as S,T&I), which focuses on economic, social and environmental impacts, and not only on S&T. Adopting this approach modifies the design of cooperative research projects considerably. Specifically, the potential adopters of the innovation are incorporated into the research project, be they producers, associations of producers, agroindustries or some other economic or political actor interested in the benefits of the knowledge or technology that is to be generated.

c) The third aspect concerns the need to get away from the narrow perspective of cooperation focused on public goods. Under the traditional, outdated cooperation model, priority is given to work aimed only at producing public goods. This is almost the opposite of the innovation approach. Of course, the problems of appropriability and rivalry (which define public goods and private goods) are, and will continue to be, important considerations as far as

cooperation agreements are concerned. However, today the most important area of cooperation is in the field of club goods, which involve issues related to appropriation but not to rivalry. Furthermore, club goods attract the interest of other actors that are not exclusively public, thus magnifying points "a" and "b" above.

d) The fourth point refers to the active search for opportunities. The regional cooperation model, which lacks resources, should tap opportunities wherever projects or activities are to be found. This means that, instead of allowing its hands to be tied by a lot of self-imposed legal restrictions, regional cooperation in LAC should "add muscle" by identifying and taking advantage of opportunities offered by more robust projects and activities, especially with the approach inherent in the S,T&I model.

In short, certain elements of this cooperation agenda stand out, such as the creation of a critical mass and a culture of innovation in strategic areas and the need to step up the search for (internal or external) opportunities, attract (internal or external) investment, promote collective learning (about management), lower transaction costs, reduce inefficiencies in contributing resources, identify opportunities, exploit economies of scale and scope, and reduce the uncertainty surrounding the adoption of technologies generated by R&D activities.

These ideas are not new to some of the actors in cooperative programs but they are for most of the actors involved in the innovation process. Nor is it simply a question of being willing to adopt them. Training in the management of R&D and innovation is required. This should be one of the first activities to be implemented under the cooperative programs.

Introduction

This study on institutional innovation in agriculture is an initiative of the Forum for the Americas on Agricultural Research and Technology Development (FORAGRO)[2]. For the Forum, the rationale and encouragement for undertaking this work lies in the need to develop a new vision of the role of research and innovation in agriculture, to promote changes in the traditional institutional framework for R&D, and to work towards joint efforts for the development of a *knowledge-based agriculture* in Latin America and the Caribbean.

We hope that this study will provide a conceptual base to support the discussion on institutional innovation and to foster the creation of an agenda for research and innovation in agricultural technology.

Several authors (North 1990; Hodgson, 1995) have emphasized the need to implement institutional innovations as a necessary condition for organizations to adapt to a new context, resulting from the major changes (social, economic environmental, technological, political, cultural, institutional) taking place in world society since the 1970s, which have accelerated in the 1980s and 1990s. But, in truth, it has more to do with fact that organizations are social bodies that evolve and change as part of the broader social evolution.

In agriculture in particular, comprehensive changes have occurred in the external environment that have affected the institutional foundations of organizations linked to agribusiness. In this sense, Díaz et al (1997) and Lima et al (2005) note the changes that have occurred in the productive process; the insertion of new stakeholders the processes of agricultural innovation; increased social pressure for organizations to perform successfully; changes in behavior and consumption habits; and growing concern over the quantitative and sustainable use of environmental factors.

All these factors offer challenges and opportunities for countries, but they also require an ever-increasing capacity to develop and incorporate technologies that promote the development of agriculture. For Latin American and Caribbean countries (FORAGRO, 2000), where agriculture is a strategic activity for economic development, benefiting from the new opportunities that have arisen means overcoming certain obstacles that have compromised the agricultural sector's competitive and sustainable development and trying to ensure that the region is better able to compete with developed and emerging countries. Although the Latin American and Caribbean countries differ in terms of their capacities, all share some common problems and needs, thereby justifying the search for cooperative efforts.

[2] Mission of FORAGRO: Facilitate solutions for the development of agriculture and forestry in the countries of the Americas, through the promotion of dialogue and technical and political alliances between the different actors that comprise the national, regional and international research and technological development systems, and between those that influence its performance (http://www.iica.int/foragro)

The importance of regional cooperation and integration is based on factors such as those outlined by González (2005), which include the globalization of technology; technological innovation as a factor of competitiveness; the need for partnerships to compensate for the low investment in S&T; and the importance of incorporating new technologies into agriculture.

To summarize, in this context we may examine two assumptions for LAC:

- A new global technological paradigm is being designed that will affect the known conditions of competitiveness in agriculture; however, the Latin American countries are moving farther and farther away from the knowledge frontier and are not making the necessary investments to advance toward it;
- Cooperation for innovation is a key element in order to play a leading role in the development of agriculture. There are numerous cooperation experiences in LAC that have had major im-pacts, but these are fragmented and are not directed at innovation – neither technological, nor institutional.

In this context, the development of research and innovation in agriculture through alliances and cooperation is seen as an alternative for promoting technological and institutional changes, which will help expand LAC's participation in world trade through the supply and marketing of more competitive products, of better quality and in sufficient quantity. In this regard, four main theses should be considered in this study:

- The general trend should be towards innovation, rather than towards R&D;
- The existing research and cooperation system in LAC is well-intentioned but fragmented and needs to be reviewed–there are many unexploited economies of scale and scope;
- Institutional innovations operate in the micro, meso and macro spheres;
- Institutional innovations should seek inspiration beyond agriculture and beyond the Region.

To guide the course of agricultural research and innovation, this study presents concepts and institutional innovation initiatives in the sector that may promote this interaction between the LAC countries. It is assumed that many countries are developing institutional innovations to expand their own competitive capacity and that these initiatives may be shared, making the region better prepared to respond to the new requirements and demands of agriculture.

In addition to an introduction outlining the objectives and rationale that led to the implementation of the study, this document contains four chapters on specific topics. The objectives of these chapters are: (i) to highlight the changes in the global and regional contexts that have influenced the course of agricultural research; (ii) to define concepts and theoretical frameworks and also map the existing institutional

framework for research and innovation in Latin America and the Caribbean; (iii) to present and discuss institutional innovations that have been implemented in agricultural research systems in some countries, as a way for research organizations to adapt to the changes imposed by the external environment.

Finally, based on the information contained in the first three chapters, we have added a fourth chapter that contains some pointers with the aim of supporting the development of a cooperation agenda on institutional innovation for agricultural research.

Chapter 1 – Global and Regional Contexts: Changes, Challenges and Opportunities for Agriculture

1.1 Some observations on the recent evolution of agriculture in Latin America

The new configurations in the international context, represented by factors such as the emergence of more open and homogeneous markets and the consequent growth of world competitiveness, have pressured countries and organizations to adopt strategies to make them more competitive globally. It is assumed that external events of different orders influence global processes and induce changes in the different sectors of the economy.

In the agricultural sector, the impacts of the different global changes are reflected in the way of understanding agriculture, a concept that has evolved from primary sector to the notion of *agribusiness*, expressing its integration with the other sectors and the economic importance of this activity. The concept of agribusiness was introduced by J. H. Davis and R. A. Goldberg, in 1957 and, as shown in Figure 1, it encompasses suppliers of goods and services to the agricultural sector, agricultural producers, and the processors, transformers and distributors involved in the generation and flow of agricultural, livestock and forest products, up to the end consumer.

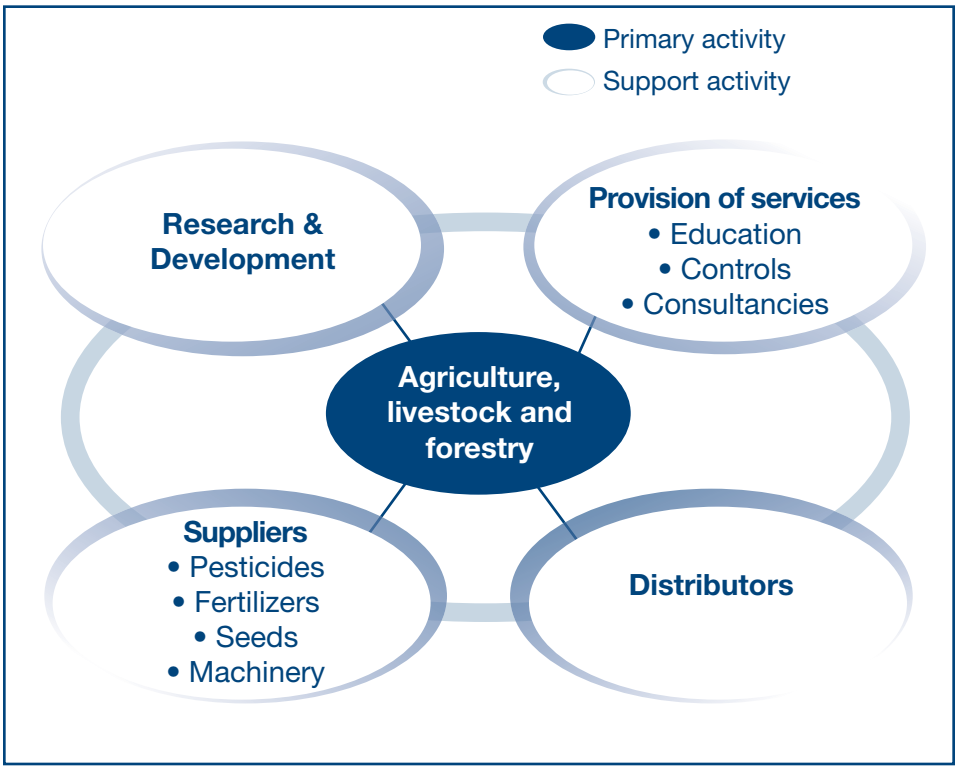

Figure 1- The Productive Chain in Agribusiness (Innovation Institute)

This development process has required (and still requires) changes in production and the development of *agriculture*[3] *with knowledge*, capable of incorporating innovations that will lead to a better use of the factors of production and give added value to the products.

The expansion of agribusiness is becoming increasingly dependent on our capacity to innovate and further our knowledge of new products and services, underscoring the role of ST&I as a necessary element for expanding agricultural activity. Far beyond food production, other business opportunities are emerging, such as rural tourism, diversified floriculture, rearing wild animals and growing medicinal and aromatic herbs.

According to Ardila (1997), if agriculture is to develop and become an increasingly important element for economic development it is necessary to: (i) invest in business development and modernize the infrastructure that supports production; (ii) incorporate modern technologies that are compatible with the criteria of competitiveness and sustainability; (iii) focus on products that enjoy competitive markets and prices. In addition, more training could be given to producers to enable them to access and manage different types of information.

These recommendations are particularly relevant for countries where agricultural activities are of strategic importance to the economy and social well-being; aligning themselves with the new context would help them advance along the road to development. However, the less developed countries also encounter more serious problems than developed countries, contradictory situations in which agriculture is presented with new opportunities, but at the same time faces obstacles and constraints to its growth.

Ardila (2000) emphasizes the availability and relative abundance of natural resources in the Americas, compared with other continents, as providing opportunities for investment and growth in the agricultural sector and in the agroindustry of these regions. Latin America and the Caribbean contain 23% of the world's arable land and 15% of cultivable land; the region also has 27% of the world's fresh water resources and 30% of the planet's tropical forests.

A study published by the World Bank, *Beyond the City: the Rural Contribution to Development* (Ferranti et al., 2005) on agriculture's contribution to development, affirms that agricultural production in Latin America and the Caribbean – including the traditional production of basic commodities, plus fishing and forestry activities – has represented approximately 12% of GDP. This percentage reaches almost 21% when food industries are included as part of agricultural production. Another important point mentioned in the study is that the expansion of agricultural activities in these regions has a significant positive impact on the growth of the non-agricultural sector. Furthermore, the importance of agriculture for the region is not only reflected

[3] Agriculture understood in its expanded concept, involving agricultural and livestock production, agroindustry and other segments of the productive chain, the rural space that transcends national borders where innumerable productive activities take place (FORAGRO, 2000).

in its contributions to the economy, but also in social aspects such as employment and rural development. Chart 1 below shows agriculture's share of GDP in the Latin American countries.

Share of Agriculture in Latin America's GDP (%, 1982)

(Source: World Bank, WDI (2003), quoted in Junguito 2005)

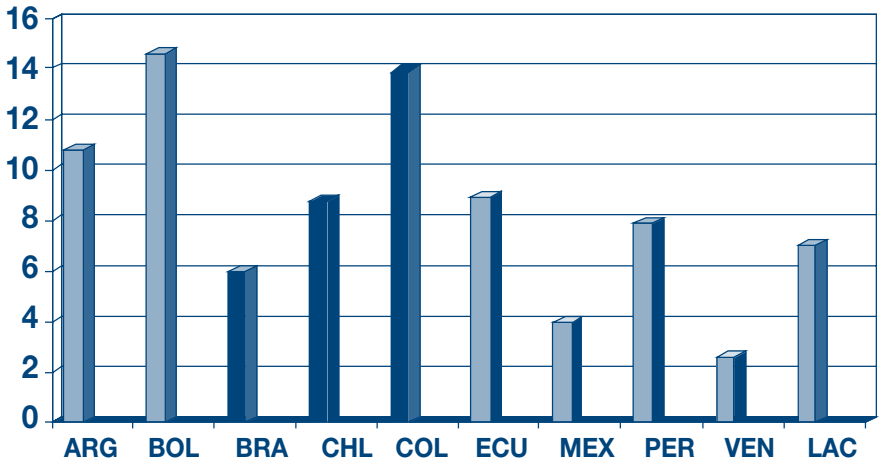

Chart 1 - Agriculture as share of GDP (LAC)

Although these indicators are important and the study by Ferranti et al (2005) affirms that the economic impact on the development of the rural sector is twice as great as what is shown in official indices, some problems have also been identified that undermine these contributions. Based on an analysis of the countries participating in the study, one of the findings was that despite the contribution made by agriculture to national development, investment in public services has been insufficient, considering that most LAC countries allocate to rural areas less than half the total spending that would be appropriate. The region's investment in R&D is low: less than 0.8% of agricultural GDP.

FORAGRO (2000) cites several aspects that make agriculture in Latin America and the Caribbean vulnerable. For example, although the region's export sector is dynamic, earnings in this area have been affected by the growth of imports. As a result, some regions such as the Caribbean report a negative balance of trade. Furthermore, areas that are suitable for agricultural production are turning into net food importers. Ardila (2000) notes the constraints caused by the limited knowledge and technologies available to the region's agriculture and agroindustry, and the low capacity - especially in Tropical America – to take advantage of existing research within or outside the region. The author notes the differences existing in Latin America between countries with temperate and subtropical climates (Southern Cone and Mexico) and the region of Tropical America, in terms of their current and potential development, and also in terms of problems and needs.

Another characteristic noted by Silva and Cantou (2005), based on documents from ECLAC/IICA (2001), is that during the 1990s the competitive efforts of the different agribusiness chains in the region had focused on products for larger markets, especially *commodities*, to the detriment of product diversification and the development of differentiated products with greater value added. The authors argue that development and innovation are essential for insertion into new markets with differentiated products.

The above characteristics are associated with the "dualism" that persists in Latin American and Caribbean agriculture. In this duality, according to Paiva (1975), modernization occurs slowly and unevenly. There is one segment of producers that has integrated into the international market, incorporating knowledge into the productive processes and adopting modern production techniques; meanwhile significant numbers of farmers continue using more traditional methods, based on low technology, and encounter difficulties in their insertion into the market.

Another aspect relates to international trade which, according to the World Trade Organization (WTO), can play an important role in promoting economic development and reducing poverty. Jank and Jales (2003) argue that agriculture is one of the most complex and controversial issues of international trade and, being a crucial issue for Latin America, cannot be treated as a secondary matter. However, there remains the question of LAC's ability to defend its positions in international agreements and to comply with the regulations that govern the international agricultural trade. The purpose of trade agreements is to promote more open markets along with the growth of trade with the region. There are three main international negotiation processes whose outcomes are of special interest to Latin America and the Caribbean: the Doha Round of the WTO; the Free Trade Area of the Americas (FTAA) and the EU-Mercosur Agreement.

The world has witnessed the so-called Doha Round, under discussion for more than four years. In relation to agriculture, the plan - at least officially - is to establish an equitable trade system that would lift restrictions and prevent distortions in world agricultural trade (WTO, 2006). However, while discussions continue, events move in the opposite direction. As we know, there are major obstacles to reducing trade barriers in agriculture, particularly on the part of the rich countries.

Developing countries have played an active role in these negotiations and special mention should be made of the coalition of Latin American, Asian and African countries in defense of a greater discipline in domestic support measures, in the quest for the elimination of export subsidies and greater access to the markets of developed nations (Jank and Jales 2003).

There are now many doubts over the future of international agricultural trade, precisely because of resistance by the developed countries to make concessions in their protectionist policies. This impasse illustrates the complexity of the international negotiations on agricultural trade.

A similar situation is evident in the discussions on agriculture in the context of the FTAA and Mercosur negotiations, two other agreements of special importance for LAC, that do not seem to find a satisfactory course. The negotiation model proposed in the context of the FTAA calls for agricultural issues to be addressed multilaterally. Jank and Jales (2003) identify four positions that have influenced the hemispheric negotiations: (i) the United States' intransigence in offering better incentives to the rest of the countries; (ii) countries such as Canada, Mexico and Chile that have already signed the agreement with the United States; (iii) Brazil, a country resistant to the US proposal, argues that priority should first be given to greater integration in South America, a view supported by Argentina and Venezuela, but not by Paraguay and Uruguay; (iv) the rest of the Latin American and Caribbean countries show interest in integrating with the United States without further demands, in order to consolidate, through an agreement, the preferential access that they receive from the US.

Unlike the coalition that has been established in the Doha Round, these diverging opinions on the FTAA illustrate the difficulty of building a position of consensus that represents the interests of LAC countries and that will strengthen the Region's negotiating capacity.

Similarly to what is happening in the FTAA negotiations with the USA, the Mercosur-European Union agreement revolves around expanding the Southern Cone's access to external agribusiness markets in return for access to sectors that interest Europe. According to Jank and Jales (2003), one difference be-tween these two agreements is the fact that the EU-Mercosur negotiations are less difficult, since these involve the positions of just two economic blocks, whereas the FTAA negotiations involve the interests and positions of many countries.

Despite this situation, it is clear that in all three Agreements – Doha Round, EU-Mercosur and FTAA – the international agricultural negotiations are faced with an impasse. However, with regard to trends, a study of scenarios prepared by Embrapa and by CGEE (2003) suggests that the international markets should maintain some protective barriers in agriculture, reinforcing the CGEE's point of view (2002) that the negotiations increasingly require a greater capacity for coordination and organization of expert teams in the ST&I segments and also specialists on matters related to tariff and non-tariff barriers and trade defense mechanisms (antidumping, compensatory rights, intellectual property, agricultural subsidies and policies on competitiveness, among others).

Another critical factor mentioned by Ferranti (2005), and one that must be addressed in LAC, is that although the region's countries would eventually benefit from a greater liberalization and access to agricultural markets, the impact of a reduction of subsidies will be uneven. While countries that export agricultural products would benefit from the measure, those that import food would be subject to price increases.

In synthesis, all the available information and data confirm that both agriculture and agribusiness are crucial to the region's economic growth and integration, even though

local vulnerabilities may also be exposed. This reinforces the need for Latin America and the Caribbean to promote the competitive and sustainable development of the agricultural sector, based on scientific and technological knowledge, and policies that will increase the region's participation in world trade, contribute to the reduction of hunger and urban poverty and be compatible with the conservation and sustainable management of natural resources.

Openness on the part of the developed countries will only happen when the conditions of production are sufficiently favorable to them. Since this is unlikely in the present technological and institutional paradigm, it will strongly depend on the creation of a new technological and institutional paradigm, different from the present productivist paradigm that has spread throughout the world during the last two hundred years. This clearly shows that the variable of technology and learning is critical for future agricultural competitiveness. In other words, the future technological changes will radically transform the bases of production, establishing new dimensions of competitiveness, and will determine who joins in and who is left out of the world's agricultural map.

In this context, the Latin American and Caribbean countries must learn how to benefit from and use their abundant natural resources. They must also overcome their limitations in relation to the more developed countries by implementing technological and institutional innovations. An important step towards addressing these problems is to identify the external factors of change and understand their impacts on agriculture and, consequently, on agricultural research and development. Such an approach is consistent with the conceptual framework presented by Janssen (2002, 2003) for agricultural analysis and institutional innovation, based on the following steps: (i) identify changes in the sphere of agricultural research; (ii) describe the different changes that have occurred; and (iii) evaluate the effects of these changes. This makes more sense if we also consider the changes that are about to occur.

1.2 Changing scenarios in agriculture

The global transformations that are bringing about changes in the agricultural sector are fairly comprehensive and interpreting the interdependence between changing world trends and the future course of agriculture tends to be more complex when we realize that to understand the development of these trends it is necessary to consider their different dimensions – economic political, social, environmental and technological.

Possas et al (1996) suggest that during periods of rapid change we should adopt an evolutionist approach to interpret the dynamics of the innovation process in agriculture and take into account the following factors: (i) signs of weakness in the current technological paradigm; (ii) the emergence of new technological opportunities; (iii) the influence of existing barriers; (iv) the relative importance of each problem-area in agricultural production; v) the appearance of new problem areas; (vi) the relative importance of strategies adopted by the different economic agents directly or indirectly involved with in-novation processes.

One way to confront the changes in agriculture is to begin from an external view, based on the analysis of global movements that influence the course of agriculture. Among the different factors of the international context, globalization is the common denominator that is mentioned in a significant number of texts that discuss the processes of change. The focus on globalization is based on the fact that this proc-ess is very comprehensive and introduces, in addition to the economic dimension, others such as the technical, social, political, scientific, cultural, institutional, environmental and commercial dimensions.

World trends modify the dynamics of competitiveness and at the same time create new opportunities for countries, demanding rapid responses at the risk of exclusion from the development process. There is a process of permanent action and reaction, where the general rules matter but are not exclusive, creating spaces for local actions. The new developments, whether economic, regulatory or technological, provoke changes in the sector's organization, such as those cited by Lima et al (2005). According to the authors, one of the factors that has affected agriculture is the increased complexity of the production chains, whereby the productive processes move beyond national borders to become transnational, with new global players strongly influencing the nature, course and priorities of agriculture. Therefore, changes in the world scenario affect the production process itself, and impose a new way of interpret-ing the agricultural sector, one that also recognizes its economic potential. This implies identifying the weaknesses of the productivist model and finding ways to adapt it in response to the new context that has been described, in terms of challenges and opportunities for agriculture.

Albuquerque and Salles-Filho (1998) consider that the three fundamental pillars of the productivist model – regulatory mechanisms, agricultural demand and the knowledge base – are simultaneously reaching their critical points and that this is leading to substantive modifications in the way of "doing" agriculture. The authors analyze each of these three pillars.

The constraints imposed by regulatory mechanisms are associated with the high cost of maintaining policies (such as subsidies, minimum prices, regulation of stocks, tariff and non-tariff barriers, and export incentives) widely used since the 1930s. The impact of these mechanisms on the public finances, together with the "free market's" inability to absorb surpluses and cover the real costs of production, have contributed to changes in the adoption of such policies.

Another aspect related to regulatory mechanisms is the increased demand for food security resulting from changes in dietary habits and problems with plant and animal health, aggravated by the globalization process itself. The term "food security" is used to refer to concerns with the supply and quality of food and also refers to food safety, availability and access to food and healthy nutrition (Nutti 2005). This view of food security/safety has led to new rules in the mechanisms that regulate commercial transactions and international agreements on matters such as price controls and subsidies, healthcare models, and the tracking and certification of agricultural products and processes.

Regarding the third factor – changes in the knowledge base – the revolution that began with molecular biology should, in the coming decade, significantly change the ways of tackling and resolving technical problems in agricultural production. For this reason, the technological trajectories typical of the productivist model now face limits to their continued exploitation. At the same time, the applications of microelectronics – whether in computer science, telecommunications or in the form of new equipment for use in agricultural production – will shape the new technological model.

In this regard, Janseen and Braunschweig (2003) point out that research systems face significantly different technological demands from 20 years ago, with changes in the emphasis of research. Thus, instead of focusing on primary production, the emphasis is shifting towards the management of agroindustrial chains; similarly, the focus has shifted from increases in productivity to improvements in food quality and safety. The authors conclude that the challenge for research systems is to change their identity": instead being "technology factories" they must transform themselves into "sources of knowledge".

From the standpoint of a development process, where the old paradigm coexists with the new, IICA (2003) considers that "*the performance of agriculture and the sustainable use of biodiversity are strongly influenced by technological changes, supported by the combined application of conventional technologies, with those emerged from the new knowledge, such as the biotechnologies*".

In this context of change, Albuquerque and Salles-Filho (1998) conclude that this is the right time to redefine the technological solutions to the main problem-areas of agriculture, especially for the less developed countries. In addition to interpreting contextual changes, we should look to agricultural research for solutions based on new knowledge, focusing on more environment-friendly technologies that contribute to increased competitiveness in agribusiness and reduce social inequalities.

Among the new issues that will dominate research, Embrapa (2003, 2004) emphasizes biotechnology and nanotechnology, both of which fall within the group of technologies and bodies of knowledge classified as *enabling technologies*. This term refers to the following characteristics: they form the basis of innumerable new technologies; they offer the possibility of integration with other technologies; they have potential applications in several areas of human activity, thereby bringing about changes people's lives (Lima et al., 2005). Therefore, as Salles Filho et al (2000a) conclude, the new technologies have the capacity and velocity to alter the routines of other S&T areas and also influence the links between areas of knowledge, organizations and society.

Agro-energy is another area of opportunity, as it should produce significant impacts on the sectors of production, trade, legislation and innovation. The Table of the world energy matrix and environmental issues confirms the importance of finding new energy sources (depletion, global warming and urban pollution). Currently, this matrix is constituted mainly by oil (35%), coal (23%) and natural gas (21%) (Campanhola, 2004). Studies indicate that there will be significant shortages of these

fossil fuels no later than three decades from now. Regardless of whether or not this prognosis is confirmed, the emission of harmful gases through the burning of fossil fuels has aggravated the greenhouse effect and may lead to the extinction of animal and plant species on our planet. This situation holds great potential for Latin America and the Caribbean, since the region has large tracts of land that could be incorporated into the productive process and used to make agro-energy an important component of its agribusiness.

In this regard, Embrapa (2003) emphasizes the importance of the following research areas: sustainable use of biodiversity; precision agriculture, tracking and certification of agricultural, livestock and forest products; and organic agriculture. Working on the new thematic areas has become necessary to advance our knowledge, since this represents a change in the process of generating and disseminating knowledge, as a multidisciplinary action using institutional networks.

New knowledge and technologies are factors of growth. The question is, what is the capacity of LAC's research institutions to accompany the new lines of research?

1.3 Agricultural research

Agriculture, as a fundamental component of Latin American and Caribbean economy, together with the growing importance of technology as a factor of economic development, means that R&D is the variable that could give these countries a competitive edge in this activity.

The study by Ferranti et al (2005) shows that the most common rate of return on investments in research and development (R&D) in LAC's agricultural sector is 40%. These authors note that during the 1990s, combined spending on agricultural research in Argentina, Brazil and Mexico represented more than 85% of the total in LAC.

Since the Green Revolution, science and technology have contributed significantly to agricultural development; however, the current global changes reinforce the need to review R&D and innovation processes. In synthesis, some of the trends that should determine the direction of research (Ardila, 2000; Embrapa, 2003, 2004; Lima et al., 2005) are:

- Changes in the global food system: internationalization of markets and of production; changes in food habits and preferences; growth of world demand for food; increased demands for food safety (certification, tracking and health standards for products and processes); greater concern with and control of environmental impacts (conservation and sustainable development);
- Changes in the S&T system: knowledge-based agriculture; advances in knowledge; mechanisms for ownership and protection of knowledge; public perceptions of science and technology; insertion of new players into the technological development process.

Based on the way in which organizations have approached the generation and dissemination of innovation in agriculture, Possas et al (1996) established six groups[4] that they regard as the main sources of innovation for the sector. The way in which these sources evolve and are interrelated with each other would largely determine the direction taken by agricultural technology. Among the groups mentioned, the authors recognize the predominance of the sector's industries and public institutions. However, they point out that the promotion of technology and innovation should necessarily include the integrated management of the different sources.

In other words, to undertake innovation in our modern times we must abandon the fragmented views of the Green Revolution, which regarded the generation and dissemination of knowledge and technology as two logically separate stages. The concept of innovation requires us to eliminate this fragmentation, so that contemporary ways of organizing research and innovation are based on the simultaneous integration of different actors and of different activities. It is therefore absolutely crucial to promote integrated forms of organization in research and innovation. The economies of scale and scope involved are obvious. Not to explore these is tantamount to investing in order to obtain diseconomies.

The problems faced by less developed countries in the field of agricultural innovation are of a varied nature. One the one hand, there is a relative shortage of resources (human and financial) and technological gaps; on the other there are organizational failings that amplify the lack of resources. In conclusion, it is essential to invest efforts in technological innovation as well as in organizational and institutional innovations. Promoting innovation is not limited to promoting R&D.

LAC's national research systems are mainly constituted by public research organizations, which need to recover their R&D capacity to contribute to agricultural development. Studies by Salles-Filho et al (2000a) and Lima et al (2005) note that Latin America's public research institutions have encountered a range of problems that limit local capacity to make progress in research on new topics, thereby compromising the institutional sustainability of these organizations. The region's science, technology and innovation (ST&I) systems are agro-centered, with little mobility and integration problems (cannibalism x synergies). Elements such as infrastructure, funding sources, technical and management teams, already considered inadequate for carrying out more traditional forms of research, become even more obsolete and inadequate in the face of demands stemming from the new technologies. The consequences are expressed in statements such as those by Lima et al (2005): "the main contribution of Latin America's research institutes has been to increase the productive efficiency of plants and animals". However, these contributions are increasingly insufficient to promote competitiveness at the global level.

[4] The sources are: private industrial organizations associated with the agricultural market; public institutions (universities, research centers); agroindustries; non-profit organizations, organizations offering technical assistance services, management planning; production units.

Therefore, with the aim of helping the institutions devoted to innovation in the agricultural sector to become more effective and efficient, we propose the development of an agenda for institutional innovation in LAC.

In synthesis, the preparation of this Agenda, especially with regard to ST&I, should consider the following aspects:

- Increasing complexity of the S&T market;
- Growing importance of R&D as a factor that increases competitiveness;
- Insertion of new actors in research, with greater participation by the private sector;
- Need to generate more environmentally sustainable technologies and renewable energy sources;
- Increased demand for technologies that integrate health and nutrition concepts.

In organizational terms, to overcome some critical factors for R&D, the Agenda should contemplate initiatives directed at:

- Developing technological capacity and making investments in infrastructure to promote advances in the new areas of knowledge, particularly biotechnology. Everything indicates that this area may create the new scientific-technological base;
- Diversifying financial sources;
- Promoting greater private-sector participation in ST&I, integrating different actors to facilitate the innovation process;
- Guaranteeing alignment between R&D and technology transfer, to create a cycle of innovation;
- Systematically evaluating the risks of agricultural activities, foreseeing scenarios, threats and vulnerabilities and measuring the socioeconomic and environmental impacts of research activities;
- Producing information to promote the development of the agricultural sector and the implementation of policies for research, development and transfer of technologies that will offset the negative impacts of R&D activities.

Chapter 2: Institutional Innovation in the Sphere of Agricultural Research and Technological Innovation

After the economic stabilization and structural adjustment polices of the 1990s, the development models for Latin America went on to include strategies for incorporating the *economy of knowledge*. This led to a review of the role of the institutions, of learning and of technological innovation, with the aim of increasing the systemic competitiveness of production at national and regional level, and adding parameters for the pre-distribution of income and the conservation of natural resources. Therefore, regional discussions and actions are now directed towards systems that focus on the development of the productive, technological, institutional and organizational forces that interact and create growth (ECLAC 2002).

In this context, with demands for the increased productivity of systems for building models of wealth generation based on knowledge, the production and S&T systems must interact more organically, at national and regional level, to strengthen the generation and incorporation of innovations and technical advances. Thus, the institutional players must be structurally reconfigured to generate and absorb the institutional, organizational, technological and productive changes that generate competitiveness, growth and sustainability.

With these issues in mind, this chapter aims to present a conceptual framework for institutional innovation in agricultural research and consider its implications for the development of institutions and for interaction and cooperation among the actors of the national and regional agricultural innovation systems. To build the conceptual, interpretative and planning framework for institutional innovation we undertook a review of the literature from two perspectives. The first considers the theoretical contributions of the New Institutional Economics, (and the Transaction Cost Approach to understanding the principles of strategic decision-making, division of tasks and the organization of systems), of the Technology or Tec Economy (trying to understand the innovation process), and of the Sociology of Innovation (concerning institutional innovations within innovation networks and systems). The second perspective involves the construction of a referent for analyzing institutional innovations in the specific sphere of agricultural research and innovation in LAC.

A review of the sources should help us update the concept of institutional innovation[5], with its implications for policymaking and the design of strategies to increase the efficiency, effectiveness and relevance of the National Agricultural Research Institutes (NARIs) and the National Agricultural Research Systems (NARS) and promote the consolidation of a regional innovation system.

[5] Institutions may be understood in the traditional sense, as organizations, and also as all types of organization, conventions and behaviors that serve as referents for performing social functions.

2.1 Theoretical-conceptual contributions

To develop the theoretical pillar that supports the design of the conceptual framework for institutional innovation in agriculture, two questions have to be answered: (1) *What role do institutions play in the generation and dissemination of innovation?*, and (2) *How is institutional innovation defined in innovation systems and networks?* The answers to these questions contain a proposal to contextualize and define the concepts of institutions, institutional trajectories and innovation, innovation systems and networks, coordination, joint development and the self-organization of institutions and systems, to contribute to an understanding of the construction and operation of economies of knowledge.

2.1.1. What role do Institutions play in the organization and promotion of innovation?

According to Hodgson (1995), institutions are "durable systems of *established and embedded* social rules and conventions that structure social interactions." Language, money, laws, weights and measures systems, customs (table manners), businesses (and other organizations) are all institutions. The author considers that institutionalism explains the emergence of institutions (such as firms or the State) using models of individual-rational behavior, leading to the unintentional consequences of human interactions.

In trying to explain how asset specificity affects contractual processes and institutional development and how the governance of contractual relations has implications for the institutional and organizational aspects of the economy, Williamson (1985) affirms that relations between organizations are established through formal and informal institutions which, together, create the institutional environment. In this sense, institutions define the limits that societies impose on themselves to structure their economic, political and social relations, related to the costs of cooperative adaptations so that transactions facilitate the efficient economic performance of society (Zylbersztajn 1995).

The growing asset specificity tends to increase the generation of value associated with their use (*ex-post quasi-rents*). Given that this possibility increases the agents' willingness to undertake opportunist actions in pursuit of extra profits, asset specialization has a strong impact on increasing insecurity in transactions. This impact on the one hand destabilizes the contractual processes (based on contracts) in business systems and, on the other, interferes with the development of institutions, leading to the organization of hierarchical structures of governance to reduce uncertainty and transaction costs.

According to Salles-Filho et al (2000b), the theory of Transaction Cost Economics (TCE) is not sufficient to explain innovation, since this implies uncertainties that are not attributable to opportunism or a limited rationale (basic elements of TCE), and the *trade-off* between hierarchy and markets is not sufficient for understanding the dynamics of institutional innovation, diversification and the emergence of new markets or of new firms. However, it does help us to construct an analytical

framework on institutional changes to explain vertical and contractual decision-making processes based on transaction costs. This is a basic feature in the organization of an institution: what should be done (contracted) externally, what should be done internally (verticalize).

In a more dynamic neo-institutionalist view of organizations, North (1990) argues that variations in the performance of economies are related to the development of institutions. North evaluates the role of institutions in economic performance, based on the notion that institutions, both informal (sanctions, taboos, customs, traditions and codes of conduct, etc.) and formal (constitutions, laws, property rights, etc.) structure all political, economic and social interactions. Institutions are created to promote order, reduce uncertainty, determine transaction- and production costs, and even the possibility of profits from economic activity. They also provide the incentives structure for the economy and, according to the development of this structure, determine the patterns of growth, stagnation, decline or *enforcement* (together with the technology employed).

This author considers that the central issue of development is the evolution of institutions that strengthen the political and economic environment and lead to increased productivity – involving incrementality and *path dependence* in the pursuit of increased returns. Thus, the institutional *framework* determines opportunities and guides the acquisition of knowledge and skills that are a decisive factor in the long-term development of organizations and of society. Although North discusses institutional changes and development, he does not explain the role of institutions in the generation and dissemination of technological and institutional innovations at the meso and micro levels of organizations.

According to Albuquerque and Salles-Filho (1993), the institutional question appears more frequently in neo-Schumpeterian works that discuss the existence of order and coordination in evolutionary processes, where technological and institutional changes are factors of imbalance in a non-static environment and at the same time emerge in a more or less established manner.

Dosi (1988) defines a technological paradigm as a model or system of solutions for specific technological problems, which includes well-defined prescriptions on the direction of technical change. Technological trajectories are, in this case, technical paths determined by principles, methods and the accumulative aspects of technology, interacting with economic forces and social and institutional factors that operate as selective criteria on the possible options. There is competition between new and old technologies, and also with new possibilities. The concept of technological trajectory supports the notion of patterns in the evolution of a technology, based on technological opportunities, learning processes and the predominance of certain *paths* in relation to others. Concomitantly, there remain strong elements of uncertainty linked to collective decision-making processes. It is precisely under these conditions of uncertainty that many variables converge to transform or create institutions.

According to this rationale, institutions compete to coordinate regular behaviors in the technological trajectories in two ways: by regulating and standardizing behaviors or by organizing interactions and coordination between agents. Thus, institutions are simultaneously the result and the determinant of different worldviews, behaviors, conventions, forms of coordination between agents and mechanisms of adaptation. In this perspective the institutions, combine with learning models and selection mechanisms to create order and coherence in organizations.

But institutions are not mere *ad hoc* creations that exist to resolve problems related to the economic rationale of the market or the lack of information for decision-making processes. They are part of the development process itself, learning and co-evolving with technologies and organizations.

Nelson (1994) incorporates an institutional analysis and relates it to the theory of product life cycle. According to this theory, initially several *designs* compete with each other and, when a model emerges as dominant, firms tend to adopt innovation processes. The consequences of these processes are changes in the structure of industry, trends towards market concentration and the transition to maturity of the industry. A design is selected as dominant in three situations: (i) it is the most efficient; (ii) it is selected by chance and resources are concentrated towards it, eventually creating barriers to the predominance of others; (iii) it is the consequence of the model's adaptation to the social-institutional context.

The *systems approach* to sectoral systems of innovation and production (SSIP) emphasizes the self-organizing character of institutions, technologies and organizations in the generation of innovation and in sectoral economic development. In the SSIP approach, Malerba (2002) defines sectoral institutions as standards, regulations, laws, agreements and conventions, models, routines, established practices and the cognitive aspects of the main players. Institutions emerge in a given sector as a result of deliberate planning or decisions made between firms and other organizations, or as a consequence of interactions among agents. In this way, the sectors are differentiated by their typical institutions and also by the types of organizations that constitute them. In some countries, national institutions have a strong impact on sectoral systems, with actions that can either favor or support a sectoral system, giving it a dominant role in the national economy, or else they can stifle development, innovation and produce *mismatches* between the national and sectoral agents. At the same time, sectoral institutions may also become important to other sectors or to the national system overall, in terms of their technological, organizational or strategic importance in the promotion of innovation activities.

This notion is important for the question of developing agricultural innovation systems. Briefly, it means that a sectoral innovation system cannot be organized without links with the national innovation system. Thus, it is not viable to build a science, technology and innovation (ST&I) system for agriculture without reference to the national system or to other sectoral or regional systems. However much we may define the limits of a sectoral system, its boundaries will continue to have a

degree (variable) of indefinition and of interdependence with other systems. In short, it is not possible to imagine an agricultural ST&I system disconnected from other sectors and systems.

It should be noted that most sources of agricultural innovation are not found within agriculture, but in other sectors with their own dynamics– the automotive industry, chemicals, materials etc. Moreover, the interactions with commodities and the food processing industry produce changes and form part of the agricultural ST&I systems.

Summarizing the answer to the question: what role do institutions play in the organization and promotion of innovation? it should be noted that according to the neo-institutionalist view, institutions act not only in terms of establishing cooperative solutions in transactions but also structure the opportunities and types of organizations that will be created, facilitating the efficient economic performance of society. They also act by stimulating and leading a *maximizing* organizational behavior, which demands the use of knowledge reserves, the development of new skills and their integration with institutional structures.

In the neo-Schumpeterian approach, institutions articulate behaviors within the technological trajectories regulating, standardizing or organizing interactions and coordination among the agents. Institutional architectures are developed that combine with learning models and selection mechanisms to generate order and coherence within organizations, with their innovative environments and changes. They also enable the *designs* of a technology-industry to adapt to their life cycle and socio-institutional context, while supporting the development of capabilities and competencies. The emergence of sectoral institutions stems from decisions or interactions among actors and institutional changes that alter the dynamics of innovation, the coordination between the agents and the boundaries between the public and the private spheres.

We therefore arrive at two important postulates:

- At the micro-institutional level, decisions are based on what to do internally (internalizing) and what to acquire externally (contract). This is a general rule both for private and public organizations (for profit and non-profit).

- The references taken into consideration in decision-making are found at the macro-institutional level.

The work of organizing ST&I systems must consider these two dimensions - macro and micro. But between these two dimensions there are intermediate aspects of the institutional framework that are key to understanding a world that is not only organized in individual terms (isolated decisions at the micro level), nor is it defined, ex¬-ante, by a given institutional situation. In fact, a significant part of systems management occurs at the meso-institutional level.

Contractual forms of organization occur at the meso-institutional level. These are precisely the solutions that allow for the best combination of micro elements with macro elements. Some specific examples in the field of ST&I are complex cooperative projects, networks and all forms of interaction that make it possible to exploit efficiencies and economies.

2.1.2. How is institutional innovation defined in innovation systems and networks?

Overcoming the linear view of the innovation process has led to an understanding that innovation is an entirely collective process, because: (i) it involves different actors with different perspectives; (ii) it looks at a common objective with different concepts, tools and perspectives; (iii) it requires a division of work; (iv) it requires the distribution of property rights; v) it has economies of scale and scope; (vi) it requires coordination. According to this view, institutional changes and advances in knowledge are essential for the efficacy of technological innovation processes. Successful innovation is conditioned by complementary innovations and by the learning that occurs alongside the generation of externalities. Indeed, the current innovation processes are largely organized around institutional changes for the consolidation of innovation systems, the formation of cooperative networks for shared learning and the coordination of supply and demand. To answer the previous question we explain some concepts that are key to understanding the problem, since in the development of a Knowledge Society the increased generation, transformation and circulation of knowledge reinforces the systemic model and strengthens the organization of networks so that they can take advantage of the synergic effects of cooperation. The progressive effects of the economy of knowledge then lead organizations to produce institutional innovations seeking efficiency, efficacy, flexibility and adaptation, based on the learning generated and accumulated through changes.

a) The conversion and circulation of knowledge

There are two approaches that help us understand the processes of conversion and circulation of knowledge: that of the "knowledge-based economy", which emphasizes the different modalities of knowledge, their circulation and their importance for economic development; and the approach that emphasizes training and the development of competencies in organizations.

In the first approach, Lundvall (1996) notes that major changes in the production and distribution of knowledge have affected the economy as a whole and therefore a re-evaluation of its institutions is required to increase their capacity to access and participate in knowledge and learning-intensive networks. The dynamics of knowledge-based economies are based on the creation as well as the dissemination and use of information and knowledge, which may be codified (transferable) or tacit (non-transferable, i.e. must be learnt through practice), and may be divided as follows:

- Know-what – (codified) refers to facts, represents information;
- Know-why – (codified) refers to knowledge of the laws of Nature;

- Know-how – (tacit) refers to the capacity or ability to do something;
- Know-who – (tacit) refers to the relational ability, of knowing who knows what and who knows how to do something.

Strategic competencies and *know-how* develop interactively and are divided within subgroups and networks, in which *know-who* is important. According to this view, the economy becomes a combination of networks that are moved by the acceleration in the rate of change and learning.

If an innovation system's "power of distribution" is a key determinant of economic performance, its policies must be aimed at offering potential innovators rapid and easy access to relevant knowledge bases. However, the main thrust of scientific and technological policies in recent decades has been to encourage the generation of new types of knowledge, relegating to second place actions to improve dissemination and access to existing reserves of knowledge.

Nonaka & Takeuchi (1997) propose a second approach– training and competencies – focusing their analysis on the process of creation, conversion and transfer of knowledge within organizations. This model is based on the assumption that knowledge is created and spread through social interaction, generating conversion processes, where tacit knowledge is converted into explicit (codified) forms of knowledge and vice versa. Thus, knowledge conversion occurs in four dynamic and interactive stages:

- socialization – tacit knowledge is collectivized and absorbed by other individuals;
- externalization – tacit knowledge is codified;
- combination – different groups/sets of explicit knowledge are systematized;
- internalization – explicit knowledge is incorporated into tacit knowledge.

Knowledge creation and conversion is not a lineal process, but instead forms a "knowledge spiral" in which the interaction between tacit and explicit forms of knowledge increasingly expands in scale as its level ascends. Thus, the creation of organizational knowledge is presented as a process that begins at the individual level and gradually expands to communities of interaction, crossing the boundaries between sections, departments, divisions and organizations (Nonaka and Takeuchi, 1997). The generation and circulation of knowledge within organizations assumes that its conversion effectively occurs in two dimensions: social/ individual and tacit/ codified.

Even on the question of training and competencies, Penrose (1959) introduced the concept of an organization's technological base to describe a set of training actions and assets that form the core of an organization's knowledge and abilities, and upon which it can even develop its strategies of competitiveness and diversification. Within this approach, the vision of resources proposed by Teece (1988a, b; 1996) has

advanced our understanding of those assets and forms of training and defined the concept of complementary assets.

Complementary assets can take different forms such as highly specialized training in marketing, production, use of intellectual property and technical assistance, which make it possible for an innovation to reach the market successfully. There are also complementary innovations that make a technology system more attractive, since control of the asset may be a more efficient mechanism to control the profits from innovation than ownership of the technology *per se*. Therefore, control over complementary assets constitutes a second line of defense for innovators with respect to the profits of innovation.

The development of complementary assets is associated with a localized, specific learning process, with strong idiosyncratic characteristics. Often, these assets are difficult to reproduce because they are based on tacit forms of knowledge embodied by individual experts. Transferring technology from the laboratory to production, or from one place to another, is a form of technological training, considered a central asset for the competitive strategy of organizations.

For their part, Cohen and Levinthal (1989) introduce the notion that external knowledge may be used to generate innovation, due to an organization's capacity for absorption. Christensen (1994) separates different forms of training - organizational, functional/technical, and by absorption- based on the learning processes that feed them. He also defines reproductive forms of training that feed off routines and fundamentally serve to improve the existing technological trajectories – or strengthen lock-in processes. In contraposition, the author describes the training dynamics that provide the basis for creating long-term competitive advantages, promoting innovation and creating new routines and training.

For the central issue of this work it is important to remember the following points:

- The governance of macro, meso and micro institutional entities depends on the development of different types of knowledge, either tacit or explicit. Cooperation mechanisms (projects cooperatives, networks etc.) may benefit enormously from structures that facilitate different forms of "knowledge";
- The governance of these cooperative entities must also focus on developing the specific and complementary competencies of the organizations involved.

In structuring sectoral or regional S, T&I systems, two aspects should be considered: a) the promotion and organization of knowledge in its different forms and b) the development of specific and complementary capabilities within organizations (at the micro and meso levels).

b) Innovation systems

The innovation systems *approach* is described by Freeman (1987), Nelson (1992) and Lundvall (1996). According to FORAGRO (2000), the determinants of innovation respond to *internal factors* in the users, which translate into competitive advantages

for investment firms. But they also respond to *external factor*s, generated by the dynamics of the institutional context, which create the conditions for accessing knowledge and technology. Therefore:

> *"The coherent articulation between both types of factors (internal and external) establishes what is known as an innovation system. This concept denotes a set of signals and institutional actors that play an important role in implementing innovation because their interaction defines the necessary flows of funding, human resources and information, as well as the organization required for a firm to acquire and implement the technological capacities to compete successfully (*Alarcón et al., *2000)."*

Since processes involve the practical appropriation of knowledge, the national S&T systems are working towards reorganization in order to consolidate the national innovation systems, defined by Metcalfe as:

> *"(...) that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technology and which provides the framework within which governments form and implement policies to influence the innovation process. As such, it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artifacts which define new technologies (*OECD 1999*)".*

In terms of policymaking associated with the concept of innovation systems, Viotti (2003) notes that the general aims are to correct "systemic faults" in the networks of institutions and linkages that support the innovation process, based on the indicators of knowledge flow, institutional mapping and integration with economic indicators. According to the report "*Benchmarking Industry-Science Relationships*", (OECD, 2002): "(...) the performance of innovation systems is associated with the intensity and efficacy of interactions between the different players committed to generating and disseminating new knowledge and new technologies. These interactions translate into an institutionalized form of mutual learning, which contributes to the creation of a store of economically useful knowledge." In other words, the effectiveness of a system is related to the division of tasks, complementarity and governance.

According to Edquist (1997), innovation systems may be supranational, national, regional, local and sectoral. This allows the analysis to focus on the institutional environment and its basic coordination mechanisms, as well as to implement or propose adjustments to the dimension that will give greatest coherence to the unit.

c) Networks and innovation

Networks are the basic units of innovation systems. Their forms and operational dynamics reveal some key issues for understanding the processes of organization and governance of systems.

The need to take advantage of economies of scale in R&D, share risks and uncertainties (Callan, 1992), exploit the complementarity of assets envisaging *scope economies*), or the emergence of new technologies that offer less rigid solutions in organizational structures, with horizontal and lateral connections between firms (Noria and Eccles,

1992), have encouraged the creation of networks to develop and exploit knowledge cooperatively. Through the action of networks, technological trajectories are now constituted by collectives that share knowledge, substituting the "supply-side" view of knowledge with another based on the collective construction of innovation.

This increases the possibilities of complementarity between public and private knowledge to overcome the rigidity imposed by conceptions based on public goods and private goods, almost an obsession among the leaders of R&D organizations (we will return to this point later). Having defined the existence or the need to create an innovation network, the key issue becomes the identification of the main players, their abilities and the implementation of coordination mechanisms among them.

According to Salles-Filho et al (2000b), institutional trajectories are what lead research institutions to participate in particular networks and to perform particular roles. The approach of the knowledge-based economy and the role of training and competencies in organizations help us understand how networks acquire complementary assets (Teece 1996) or develop essential competencies (Prahalad and Hamel 1990).

Since cooperation in innovation processes is an option that takes advantage of economies of scale and scope in R&D activities, the complementary nature of the asset strongly influences institutional efficiency, and access or ownership of complementary or specialized assets determines a player's role within the innovation network.

According to Callan (1995), based on the characteristics and types of innovation networks, strategies and policies can be produced to optimize their performance. In emerging networks, interventions should encourage alliances, bring together the main players, and increase the circulation of information, competencies and equipment. In stable networks, strategic actions should foster competition and combat inflexibility, acting to improve mechanisms of protection, compatibility of technologies or the technological model, avoiding the premature departure of participants.

If a network is incomplete, the policies must try to create the missing components to strengthen it. Callan (1995) argues that networks are organized in three main spheres: scientific, technological and related to markets. There are two intermediate components: transfer and development; and an external component: financial. Finally, if the network is of a dispersed nature, its optimization depends on policies aimed at increasing the degree of convergence and interactivity of the chief players in the components that are weakest.

Working from this type of perspective helps to promote substantive advances in regional and sectoral cooperation. In essence, it is a question of promoting management skills that can lead to technological advances and innovation.

In technologically dynamic environments, organizations must adjust their format to the systemic nature of innovation processes, converting their individual skills into sources of opportunities (Nelson and Winter, 1982). The use of the *networks concept* has become important in the innovation process of research institutions because it allows these to observe and evaluate strategies to open up their

institutional environment, increase their interfaces or increase the flexibility of their multidisciplinary and multi-institutional research groups.

Networks immersed in innovation systems have provided an important tool to expand the dialogue and connectivity between institutions, consolidating mechanisms of governance and the exploration of complementary assets. They help to better identify the institutional challenges facing the innovation system, incorporating numerous players who interact in the productive structure, in research organizations and in the institutional structure within the innovation process. As mechanisms that seek synergic effects between the main players, the networks also make it possible to develop new methods, concepts and forms of institutional action that contribute to a more productive use of the resources available in the national innovation system.

International cooperation networks also play an important role in the consolidation of national innovation systems. They have contributed to the increased efficacy of the national systems by providing training for human resources, new knowledge and advances, research inputs, technological information, regulations and methodological or funding guidelines. Essentially, these networks have contributed to the exploitation of economies of scale and scope, reducing redundancies, resolving conflicts and taking advantage of opportunities.

d) Institutional Innovation

The interactive model of the innovation systems underscores the importance of forming cooperative research networks, sharing knowledge, linking supply and demand and institutional innovation for the consolidation of national systems and the building of *economies of knowledge*. As mentioned previously, the increased generation, conversion and circulation of knowledge reinforces the need for systemic organization and cooperation between the leading actors in order to share knowledge and generate innovations. This leads organizations to internalize the new management model, learn new skills and develop cooperation and competitiveness. Thus, institutional innovation, innovation networks and systems, and the conversion and circulation of knowledge, create a cycle of co-development of technological, organizational and institutional innovations and of self-organization.

According to this view, because institutions are an intrinsic part of the development process, they learn and evolve over time- and, like technologies, have a history, accumulated experience, uncertainties and tacit-specific knowledge, with life cycles that are linked, to a greater or lesser degree, to the technological trajectories and paradigms – the definition of the concept of institutional innovation is complex because it must allow institutions to be understood from the point of view of their trajectories, organizational changes, and processes of interaction, cooperation and learning. At the same time, they must be contextualized within innovation systems and networks, making reference to their roles and spaces, as well as to their sectoral and disciplinary dynamics.

Institutional innovations encompass changes such as modifications of mission, legal format, organization of institutional infrastructure, administration, management of

research and competencies, and also in ways of articulating interactions, cooperation and coordination with the main actors, access to resources and financing, contractual arrangements, etc.

In general, institutional innovations seek to:

- promote new ways of valuing and using assets;
- develop new assets, better adapted to the technical-economic context;
- respond to increased inter-institutional competition due to the emergence of new organizations or the changing roles of existing ones; and,
- develop flexibility and the capacity to read and incorporate contextual changes and generate anticipation.

Conceptually, as shown in Figure 2, below, institutional innovation may be analyzed at two levels: individual analysis of organizations and systemic analysis (of networks, regional, national innovation systems). Innovations also fall into two basic categories: incremental innovations, or radical improvements and innovations, or changes.

Analysis of innovation at the individual level corresponds to processes of change and reorientation in institutions and organizations, to gain efficiency, relevance and competitiveness in the context of their insertion in the innovation system– innovation at this level affects the system to a greater or lesser extent, but aims to modify the role and space of the main players and their competitive insertion. As an example of institutional innovation we can mention institutional and organizational reorientation and restructuring and changes in management systems, assets and competencies.

At the systemic level of innovation, we find more general changes that lead to the introduction of new solutions - institutional frameworks and solutions that directly impact the integration, regulation, governance and coordination of the system. Examples of institutional innovations that directly affect the institutional framework of systems and networks and produce changes in the role of the State, are the policies on innovation, intellectual property, financing and human resources, mechanisms for prospecting and disseminating technological information, technical standardization, cooperation and transfer programs, formation of research networks and the creation of agencies or institutes.

	Incremental Type	Radical Type
Level of organizations or institutions	Institutional reorientation Organizational restructuring Changes in the management system Adaptation of programs and projects portfolio Adjustments to assets and competencies Improvements in institutional efficiency "Cosmetic" innovations	Reconstruction of the institutional or organizational matrix within a new institutional paradigm Changes in core competencies New legal arrangements
Systemic Level	Adjustments to the regulatory framework Innovations in the management and coordination model for strengthening and improving the system's functions and institutions; Improvements in efficiency regarding allocations, productivity and greater focus	Introduction of new stakeholders New legal frameworks New models for organizing and structuring innovation system New forms of funding, governance and ownership Changes in the institutional paradigm

Figure 2: Types and Levels of Institutional Innovations[6]

With regard to the *types* of the institutional innovation, these may be incremental - consisting of legal reforms, reorientation of behavior or organizational and administrative changes that do not alter the original institutional or systemic matrix - or radical, bringing about more profound changes in the organizational structure, establishing new institutional cycles, or even a new paradigm. There are also institutional innovations that may be termed *cosmetic*, which modify a part of the structure, the administration, regulations or organization, without substantially altering the institution and its overall organization. Figure 2 above summarizes these concepts in a matrix showing the types and levels of institutional innovation.

Based on this review, we can define innovation as a process that reflects the social appropriation or "ownership"(via the market or not) of products, services, processes, methods and systems that did not exist previously, or of some new characteristic that differs from the prevailing ones. Institutional innovations are the changes introduced in organizations and institutions at the macro, meso and micro levels, either reacting to or anticipating confirmed or expected changes. They may be more or less radical and may occur at the level of organizations, countries and the world. It is also clear that the road ahead for institutions, towards societies of knowledge, requires planning for innovation and the integrated management of research and selection procedures at the macro, meso and micro levels of economies and systems.

[6] As noted in the next chapter, institutional reforms in LAC have been concentrated in the NARIs, with changes aimed at achieving operational efficiency and modern management, but not innovation. Little has changed in the NARSs, which remain competitive and cannibalistic organizations, lacking in systemic vision.

2.2. Analytical framework and institutional innovation in agriculture

Based on the concepts outlined in the previous section and on the analysis of the institutional trajectory of agricultural research in LAC, described below, the purpose of this section is to briefly review institutional innovation in agriculture. It discusses the implications for the organizational development of institutions, networks, systems and relations of interactions and cooperation at the national and regional levels of agricultural innovation.

2.2.1 Life cycle, trajectory and trends in agricultural R&D institutions

Martínez Nogueira (2002) considers the National Agricultural Research Institutes (NARIs) as the core founders of the National Agricultural Innovation Systems (NARS). The NARIs in LAC have similar histories, features and a certain institutional isomorphism. Therefore, despite their differences, they share analogous characteristics and life cycles, with an institutional rationale that responds to an evolutionary dynamic whose configurations have a certain reciprocal coherence. With this analogy, the author suggests links between contextual situations, prevailing concepts on research and transfer, the adoption of strategies, institutional paradigms and models of organization and management, according to the stages of the life cycle of the NARIs, namely: establishment and development, consolidation and adaptation, maturation and reformulation, transformation and recreation.

For Martínez Nogueira, the rationale for institutional development was and is determined by the complexity of the institutional framework. From a vision strongly associated with state research institutes, this rationale shifted to a conception based an institutional research and transfer system, with the aspiration of creating national systems for the regional level, or achieving a greater insertion in global mechanisms.

Initially, the NARIs formed a vertical system for the division of work at the international level. Their basic role was to adapt research and transfer technology, as a public good, to help producers increase their productivity. However, the technology packages came from developed countries and international research centers, which controlled the articulation between basic and applied research to produce technology and innovation.

This hierarchical and linear model had some positive points, such as the establishment of agricultural research institutions in less developed countries and in LAC. However, beginning in the 1980s, this model suffered a major crisis stemming from changes in the technological model of agriculture (exhaustion of the productivist model) and the redefinition of the role of the State and its funding capacity (Salles-Filho, 1995). Since then, a new institutional rationale has emerged with new actors generating a multiplicity of offers, in contraposition to the virtual monopoly of the NARIs under the linear "supply-side" agricultural innovation model of the previous period, together with changes in property rights and ownership systems.

Chaparro (2000) considers that the NARS emerged on the basis of knowledge linked to genetics, chemistry and mechanics, as public goods. In the context of the "*agriculture of knowledge*", new scientific knowledge and different disciplines, local

learning and the retrieval of farmers' know-how all converge to increase the bio-economic efficiency of integrated ecosystems. The fields that are in the vanguard of this technological dynamism are: biotechnology, agro-ecology and informatics/ microelectronics. We should also mention the role of nanotechnology - a revolution that begins with chemical inputs - and genetics.

In the present context, producers' organizations and NGOs have become closely involved in the processes of designing and implementing technology transfer policies. In some countries, major research foundations have emerged, funded by private contributions and international cooperation. Another significant aspect in the provision of research and technology services is the growing importance of university research centers– due to the need for scientific inputs for innovation – and the consolidation of specialized institutes, private firms and technical groups. (Ardila, 1999).

In a technology market with new actors and new structural conditions, complementary innovation, shared learning and the generation of externalities become important factors within innovation networks.

Under this rationale, the direction of technological and institutional change is associated with the consolidation of systems that allow for organic linkages between supply and demand, to the point where supply and demand are no longer discernible as distinct categories, but are managed as part of the overall innovation process.

2.2.2 Developing the analytical framework

The construction of an analytical framework for institutional innovation in the sphere of agricultural research and innovation, directed at the regional dimension, is based on a review of the relevant literature and on a systematization of concepts and contributions from authors such as Piñeiro et al (1999), Ardila (1997 and 1999), Moscardi (2000), Chaparro (2000), Janssen (2000, 2002 and 2003), Martínez Nogueira (2002), Salles-Filho et al (1999 and 2000) and from official documents of IDB, IICA, ISNAR, GFAR, CGIAR, FORAGRO and FONTAGRO.

Figure 3, below, summarizes the conceptual systematization of the literature, providing a framework with five levels of analysis (one individual and four showing the aggregation of systemic levels), describing the trends and types of institutional innovation at each level of institutional organization in agricultural research. Although the levels of analysis are organized sequentially, corresponding to the degree of aggregation, their interfaces are multilevel in the interaction between stakeholders, networks, systems and mechanisms[7] .

[7] Is important to emphasize that in designing the levels of aggregation, the networks were considered without making a distinction between their national, regional or global scope, to simplify the model in a synthetic structure.

Level	Trends	Institutional Innovations
National Agricultural Research Institutions (NARIs)	Convergence, integration, administrative autonomy, flexibility and awareness, competitiveness within innovation system	Deregulation, decentralization, privatization, social control, reorganization of institutional infrastructure, administration, research and competencies management, cooperation, coordination with other stakeholders
Institutional arrangements and networks for institutional innovation	Expanding dialogue and connectivity between institutions, circulation of competencies and exploitation of complementary assets	New institutional solutions and mechanisms for technological cooperation and innovation, good governance and coordination among stakeholders to share inputs, standards, information, methodologies and equipment
National Innovation Systems	Overcoming the linear model, interaction of national capacities, development of networks and consortia for systemic learning	Strengthening of institutions; new research mechanisms and models; new institutions, standards, regulatory frameworks, stakeholders, solutions and networks; new forms of organizational architecture, coordination and innovation management
Regional Innovation Systems	Transformation of NARIs and NARSs to exploit the synergic effects of regional institutional diversity and joint financing capacity	New institutional solutions, organizations, networks and legal frameworks to take advantage of complementary strengths and convergences between the national systems; coordination to generate information, assist in decision-making, procure funding, transfer knowledge and provide training
Global Cooperation Systems for Innovation in Agriculture	Consolidation of regional research strategies and institutions; support for food security, rural development and environmental sustainability programs	New regulatory and institutional framework for agricultural research, innovation in global, regional and national liaison and decision-making bodies; new agricultural development policy models; and new funding mechanisms

Figure 3 - Institutional Innovations: Levels, Trends and Characteristics.

In addition to the systemic vision, the proposed framework may help in the analysis of institutional innovations, referencing these within each level, exploring them, identifying the main stakeholders, points of friction and weaknesses, strategic guidelines and actions. It may also provide a level of detail specifying the main players, infrastructure, trajectories, trends, mechanisms of interaction, coordination, governance and development, regulatory frameworks and research strategies,

programs and projects. It may even refer to the links between two or more levels, describing their interactions, interfaces, hierarchy, reciprocity and *feedback*, conditioning factors, determinants, and co-evolution.

An explanation of the context, trends and actions related to institutional innovation at each of the levels included in the analytical framework follows below.

a) Level of national research and development organizations

According to Chaparro (2000), agriculture with knowledge marks the start of a long-term technological cycle, guided by a new scientific and technological paradigm that is transforming the dynamics of technological change and agricultural production processes. In this new cycle, the techniques of modern biotechnology, sustainable development models and the new information and communication technologies are generating changes in the organization of scientific research and in the organization and actions of the NARIs. This context requires the agricultural research institutions to become better integrated in innovation networks, linking researchers with extension workers, intermediaries and producers. They must also engage in knowledge management, systematizing local knowledge to complement universal scientific knowledge and seeking a synergetic integration of the two through interactive information systems and participatory research.

Under this perspective, innovations in the NARI model seek to modernize these institutions according to the new paradigm of technological development in agriculture and also to overcome their isolated forms of action, reminiscent of the previous model, in order to consolidate the NARS. Regarding the latter, in addition to considering the new role of the State, it is also important to consider the role of the universities, the production sector and NGOs.

Janssen (2002) notes that innovations in governance, funding and research models have transformed some NARIs from technology factories into sources of knowledge. This affects the organization and structure of research systems. The operational and strategic rationale shifts its focus toward network and knowledge-based economies.

According to Martínez Nogueira (2002), the changes in agricultural R&D institutions have followed two trends. The first is institutional reorientation, a process of maturation in the original institutional model, based on strategies to reform legal aspects, organizational structures and integrate these in response to demand, to make more efficient use of the NARS' research infrastructure.

Although this improves the original model in terms of the plurality of competencies, multiplicity of programs and types of research, technologies and products, it does not substantially alter the organizational matrix, or the operational and funding models.

The second trend involves transforming and recreating the NARIs under a new institutional rationale, based on a new paradigm and institutional development cycle, through the structuring and consolidation of the National Agricultural Research

Systems. Institutional changes and innovations based on the new paradigm generate a *re-institutionalization*, with the reconstruction of capabilities, the revision of traditional forms of cooperation, and the design of research strategies supported by national and international complementarities. Therefore, in the change of paradigm, the support of regional cooperation bodies is indispensable in the reconstruction of the institutional infrastructure of the NARIs.

Martínez Nogueira (2002) also explains that a mere institutional reorientation of the NARIs leaves gaps in their vertical coordination and also between the units that internalize knowledge resulting from basic and strategic research and the incorporation of technologies by producers. This causes redundancies in the performance of tasks and ambiguities in defining the domains and competencies of the different organizations, with loss of aggregated efficiency within the innovation system. Thus, the redefinition of the NARIs ' institutional/organizational matrix primarily requires an innovation policy, including the definition of areas of competence and strategic guidelines.

According to Salles-Filho et al (2000), current trends in the organization of research are converging towards the search for organizational models and institutional solutions that strengthen the competitiveness of the institutions. This is a response to an environment that selects organizations whose basic attributes include administrative and financial autonomy, flexibility and agility to respond to demand, along with the capacity to detect and monitor trends, i.e. *awareness*. This may also be conceived as a "warning" or forecast system.

Details of the attributes: with regard to autonomy, institutional decisions should be an affirmation of individual competencies linked to a larger institutional rationale, but institutions may define the priorities, criteria and standards that will govern their conduct without dispersing their activities. Four aspects of autonomy are important: (i) autonomy in the organization of research, including setting priorities, creating teams, defining infrastructure, and also coordinating with internal and external co-participants; (ii) autonomy in the management of human resources, staff training, 'hiring and firing', performance evaluation, capacity to promote internal organizational configurations, administer and integrate existing competencies; (iii) financial autonomy, control over the use of resources, results and goals, institutional competitiveness; and (iv) a patrimonial policy aimed at establishing greater autonomy in management is essential to achieve financial autonomy and institutional competitiveness.

The concept of flexibility refers to the organization of R&D activities and services, based on the perspectives of the internal management and on the capacity to organize competencies and eliminate the structure's compartmentalization (i.e. sections, departments), both in terms of human resources and laboratory infrastructure, equipment, experimental facilities, etc. to respond with agility to the demands of society. This means implementing, in practical terms, an internal networked structure, with the necessary capacity for reconfiguration, to support the institution's dynamic

insertion in S&T systems and innovation networks. This structure should enable the institution to organize itself, based on its own competencies and skills, and reconfigure its research teams, infrastructure and institutional base.

The attribute of *awareness* (monitoring the milieu and detecting trends), which involves capacity building to detect changes in the milieu, is also an essential requirement for the competitive insertion of the NARIs. The purpose of the routines developed in a traditional institution is to maintain a record of excellence in the already consolidated spheres of activity. But if highly specialized routines reduce the margin of error in decision-making, they also make it difficult to recognize opportunities for institutional action and interdisciplinary coordination, both within the institution and between institutions with different specialties.

Therefore, there are technical and political aspects that should be taken into account in institutional reorganization processes. The division of tasks and more technically appropriate organizational models may lead to greater efficiency in innovation activities. This, however, is not a purely technical action. The changing perception of governments regarding the role (and functioning) of innovation, and their support for these institutions to assist their insertion into innovation networks, is an essential condition for the success of efforts towards the institutional reorganization of research. Forging new links with the public sector and expanding relations with the private sector is key to restoring the research capabilities of public institutions.

According to Ardila (1999), the main changes required to improve the efficiency of the NARIs model in LAC have been: (i) legal deregulation; (ii) intermediate or radical decentralization; (iii) privatization of management services; (iv) strengthening technical training and policy coordination; (v) mechanisms for social oversight by users or consumers; (vi) international opportunities for contracting human resources and (vii) strengthening of self-financing mechanisms (policy on intellectual property and rights for the purchase and sale of technology, technical assistance contracts).

b) Level of networks and institutional solutions for innovation

Martínez Nogueira (2002) notes that there is a new technological paradigm, a progressive move towards the incorporation of more activities and with a more integrated form of implementation. This provides a roadmap for the construction of networks and systems made up of dynamic institutional systems for the division of work in joint projects. Networks are mechanisms for developing scientific and technological capacity; at the same time, they are mechanisms *under* development, with increasingly numerous and diverse interactions, with activities that progressively mobilize and generate new training initiatives.

All networks have some common attributes: (i) emergence based on an agreement between a multiplicity of participants with interactive relations; (ii) contributions, cooperation and complementarities; (iii) mutual use and expectation of benefits; (iv) issues of common interest; v) mechanisms that ensure the coordination and

continuity of the interactions and (vi) resources to finance their activities. The plural-ity of networks and mechanisms also reduce the system's vulnerability, while the financial uncertainties and operational problems of a network do not affect the systemic relations as a whole. Networks may be constituted and operated as national innovation *intra-systems* or *inter-systems*, in the sphere of regional cooperation and international mechanisms.

The concepts of networks and innovation systems are complementary in an understanding of the links and configurations of stakeholders in market and non-market spaces, and the role of the State and of public policies in their relations and coordination with the private sector. The concept includes factors that support innovation such as physical and institutional infrastructure for research, the formal education system and the system of promotion and financing. It also helps to describe the transformation of the institutional framework in the context of interactions extending downward, directed by a model of *coordination and integration* of priority-setting mechanisms, instruments to encourage the marketing of cooperative research, together with the important indirect effects of "networked operations" and of the flows of tacit knowledge, in promoting a broader and more enduring collaboration (OECD 2002).

From the perspective of *inter-systems*, innovation networks help us understand the flows of combined resources, training and transfer processes that transform the base of the national innovation systems. In less developed countries, identifying and evaluating their specific assets and local advantages becomes an important strategy for public policymaking aimed at expanding the innovation networks and making the national system more competitive in the international sphere. This process highlights the importance of learning capacity and knowledge generation in research and training institutions and of the institutional system's internal competitiveness.

Martínez Nogueira identifies seven types of networks for technological and institutional cooperation in agriculture: (i) information networks; (ii) networks for the exchange of genetic material; (iii) networks for training and resource development; (iv) networks that focus on specific problems or products; (v) networks that identify with priorities/projects of common interest, which are executed independently by the participating institutions; (vi) networks in which the design and execution of projects is undertaken jointly by the institutions; and vii) regional network systems that exploit their different capabilities, promoting the specialization of their members and sharing the results.

Institutional innovation in cooperation networks occurs when there are changes or when new mechanisms and institutional arrangements are introduced for technological cooperation and innovation, or when new systems of governance and coordination are implemented, stemming from changes in the institutional regulatory framework, or in the way of organizing research, or sharing inputs, information, methodologies, standardization and equipment. In the regional institutional networks, innovation mainly consists of changes in the communication, cooperation and integration bodies linking national, regional and international research and innovation systems.

c) Level of the NARSs

According to Moscardi (2000), increases in agricultural productivity have historically come from four sources: (i) from the adoption of improved technologies; (ii) from the application of more effective policies; (iii) from improvements in physical and institutional infrastructure; and (iv) from improve-ments in the education of the rural population. In the author's opinion: "(...) Although all these sources need the support of agricultural research, what they require most from it are improved technologies, policymaking and institutional design. Nevertheless, traditional agricultural research has been directed at generating new technologies".

Piñeiro et al (1999) note that the tension between globalization and fragmentation, together with the option of integration or exclusion, makes it imperative for the countries of the region to modernize their structures, proceed to open up their economies and encourage the effective operation and competitiveness of their markets. In this context, nearly all the LAC countries have adopted a model similar to the Economic and Institutional Reforms. The first generation of Institutional and State Reforms – during the 1980s – restored the role of the markets as a fundraising mechanism. The second generation of reforms, during the 1990s, modified the institutional frameworks so that markets would respond to their attributes of competition and quality. The third generation should focus on institutional and organizational development, based on strategic guidelines that include local, national and regional specificities, the trajectory and capabilities of the actors and public-private sector integration.

In the context of the global economy, national competitiveness is linked to the capacity to align macro-economic policy instruments and the development of infrastructure, within an institutional legal framework. In this same scenario, agricultural competitiveness is associated with the capacity to generate and incorporate technological innovation, guarantee health and safety, commercial quality, and promote the development of markets and exports, business training and physical infrastructure.

With regard to the third generation institutional reforms, institutional capacity-building is indicated as the way to overcome problems of production, technology, markets and infrastructure. For this reason, it is necessary to design strategies for institutional actions within the NARSs that focus on the reform and strengthening of agricultural research institutions.

The authors stress the importance of having sufficient technical- institutional capacity in the NARS to evaluate the future conditions of the markets and of agricultural technology and to design policies that take advantage of opportunities in the international sphere. Such technical capabilities should be complemented with the capacity to participate in international and regional negotiations and agreements, and request training programs for human resources with strategic competencies, financial resources to carry out prospective and strategic planning studies on which to base negotiations, as well as the development of an appropriate institutional infrastructure

that allows for coordination between ministries, government departments, institutions and stakeholders.

According to Salles-Filho et al (2000), the changing role of the State, technical/scientific changes, the new convergence models and the globalization of markets have all had a strong impact on the operational dynamics of the NARIs and their environments. In this context, five factors or dimensions guide the analysis and explanation of the institutional changes under way at the level of the NARSs and mark the reorganization and insertion of the NARIs in the innovation system of: (i) diversification of the sources and mechanisms for funding research; (ii) redefinition of the stakeholders, their spaces and their roles; (iii) interaction and coordination between stakeholders; (iv) different sectoral and disciplinary dynamics; and (v) the role of the public sector and new contractual arrangements with the State.

To understand institutional innovation in the agricultural research systems of five industrialized countries[8], Janssen (2000) developed an analytical framework that attempts to define the changes in the context of agricultural research and, in response, the different modifications made to the systems. In the analytical framework, by changing the context we redefine the objectives and responsibilities of research in three dimensions: (i) in the demand for technology and knowledge; (ii) in the ways of producing knowledge and technology; (iii) and in the roles of the public and private sector. There are two ways in which research systems typically respond to contextual changes. First, by increasing the system's efficiency, through strategies to strengthen the operation and internal organization of existing institutions. Second, by making the system more relevant, particularly through institutional innovation, introducing new mechanisms and research models or creating new institutions. Janssen notes that the changes observed in each country tend to be a mixture of strategies to increase the *efficiency and relevance* of research systems.

Institutional innovations in research systems fall into three categories: (i) changes in the governance of the system - scientific advisory bodies, governing boards, ministerial jurisdictions and functions, decentralization and privatization processes; (ii) changes in the funding structure, such as a separation between financing and execution, introduction of matching funds (co-financing), surcharges and new contractual arrangements; (iii) changes in the model of research implementation, creation of networks and *joint ventures*, incorporation of universities into research systems and multi-institutional programs. Janssen also points out that the boundaries of change in agricultural research systems are increasingly fluid, shifting from "hard" systems to fluid networks in the developed countries. This happens because the main sources of technological change (information sciences, biotechnology) are totally or partially outside the agricultural sector and the costs of the new methods are high and require cooperation among institutions.

With regard to the NARSs of developing countries, Chaparro (2000) notes that these

[8] United States; Australia; Switzerland, the Netherlands and the United Kingdom. Some of the innovations analyzed by Janssen are described in Chapter 3.

perform a critical role in promoting food security, reducing rural poverty, promoting sustainable development and strengthening the competitiveness of agriculture. Their mission is also to ensure that technology - including international technology - reaches the producers, by strengthening them through extension services and technical assistance. In the new cycle of technological change in agriculture, there are three main challenges facing the development of the NARSs: (i) the need to modernize research centers and their infrastructure; (ii) the development of the NARI model vis à vis the NARS model, and its new actors; (iii) the need to rethink international and regional cooperation strategies to target and centralize national investment.

Ardila believes it is necessary to develop appropriate policies to adapt the NARSs to the new technological paradigm, evolving towards a technology generation and transfer approach (linear model) for innovation management. From this perspective, agroindustrial producers are the key players in the quest for greater competitiveness through technological development, since by working with an expanded vision of markets, based on the notion of production chains, transformation processes, multiplicity of actors, specialized interfaces and value added, agroindustrial entrepreneurs become strategic agents in stimulating research and innovation. For this reason, efforts to strengthen and generate opportunities for agriculture within national economies, has focused on the integration of agricultural and agroindustrial policies and agro-industrialization.

The above complements the view of Martínez Nogueira (2000), who considers that the institutional transformation of the NARSs should be aimed at building value added innovation chains that include producers' organizations and technology distributors, farmers, producers of inputs and training agencies. Capacity-building within the system, training for producers, the promotion of complementary innovations and the development of externalities that can be internalized at regional level, should form part of these objectives.

d) Level of the regional system

The institutional innovations in the regional innovation system consist of new institutional solutions, organizations, networks and legal frameworks that take advantage of the complementarities and convergences between the national systems; and regional coordination to generate information, decisions, financing, transfer and training.

The literature on regional cooperation in agriculture suggests the need for the institutional transformation of the NARSs to advance the process of consolidation of a regional agricultural innovation system. Given that in agriculture the public research institutes form the core of the NARSs, the current expansion of regional cooperation depends on institutional changes and innovations, within the new institutional paradigm, at the level of the NARIs, enabling them to shift from the local and national dimensions to the regional and global dimensions.

The CGIAR Document (2001) notes that the principles governing the regional approach are: coordination, participation and association within a system or

framework that produces impacts through investments in agricultural research. The system follows the configuration of: objectives, instruments, context, processes, implementation and impacts.

For Moscardi (2000), globalization implies greater specialization in agricultural production, according to each country's natural resources and agro-ecological characteristics. Martínez Nogueira (2000) affirms that the construction of a regional system depends on the design of institutional strategies that take advantage of the complementarities between national innovation systems. For this to happen, the institutional transformation of the NARSs must be directed at: (i) generating complementarities in functional specialization and geographic differentiation; (ii) incorporating a division of work into economies of scale and scope; (iii) capacity-building and training; (iv) developing and internalizing the externalities of innovation; reducing transaction costs among stakeholders and increasing the synergies; and v) increasing the efficiency of investments and optimizing comparative advantages. Therefore, in the new paradigm of technological change in agriculture, the guidelines on institutional change for regional cooperation are to increase the governance and coordination among the actors involved in the organization of innovation.

Martínez Nogueira also notes that regional cooperation in LAC has passed through two different objectives and organizational phases. Initially, cooperative mechanisms were developed around the inputs, processes and products of research. Later, mechanisms of dialogue and coordination among stakeholders were incorporated to finance joint projects and share knowledge in technology research and development. The tendency nowadays is to consolidate these mechanisms in order to promote the institutional convergence of the regional NARSs and adapt the institutional and legal frameworks of each country bearing in mind: (i) the orientation of science, technology and innovation policies and intellectual property; (ii) the regulation of access to human, technological, financial and biological resources; (iii) the establishment of research institutions for regional cooperation; and (iv) the generation of training, competencies and institutional diversity. Therefore, institutional innovations are urgent for the consolidation of the regional systems and the emergence of new institutional solutions, organizations, networks and legal frameworks that take advantage of complementarities and convergences between the national systems and that also generate regional coordination, information, support for decision-making, financing, transfer and training[9].

However, certain problems hinder regional integration, according to the FORAGRO Document (2000), since national organizations have little confidence in the effectiveness of the current integration mechanisms and face serious difficulties in obtaining resources to participate more actively. In many cases, countries may utilize the results of collective regional efforts without participating in their financing (*free-rider effect*).

[9] Institutional innovations that are being consolidated in FORAGRO, FONTAGRO and INFOTEC.

Another major obstacle to regional integration is that cooperation organizations may transfer technologies to neighboring countries that compete with each other in the market. The opposite argument, in favor of cooperation, suggests that the well-coordinated technological integration of the region may overcome these problems by offering advantages stemming from synergic effects, reducing transaction costs, increasing the capacity to finance joint research projects, increasing regional competitiveness in the global market and generating greater negotiating power in international trade agreements.

According to FORAGRO's Medium Term Plan 2002 – 2005, the regional institutional framework is comprehensive and varied, but its connectivity is very weak. The projected and expected impacts of FORAGRO on agricultural research in the region are: (i) assessment of R&D issues in decisions related to agricultural technology in national and regional policymaking; (ii) definition of a Regional Agenda of priority actions; (iii) greater visibility of the actors and *stakeholders* and more efficient regional and subregional cooperation; (iv) greater influence by the region on the agendas of the international system (CGIAR and GFAR) and; (v) consolidation of a Hemispheric Innovation System for the agriculture of the Americas.

The consolidation of *agriculture with knowledge* also involves a very different approach to property rights, compared with the previous model, since the convergence of scientific knowledge, greater mobilization and training of human resources and increased spending and financial investments, together with local expertise and know-how, is occurring at a time when greater opportunities open up for the ownership of knowledge and of technological innovations.

The growing importance of intellectual property rights affects the main activities of the NARIs and their technology-supply objectives and roles within the innovation system. For Martínez Nogueira (2002), in addition to the different nature of the stakeholders, of the ownership systems and of the scientific capacity demanded by the new technologies, the NARIs have lost the competitive advantages they had accumulated in their institutional trajectories, under the rationale of supplying public goods. This has also affected the cooperative relations among national systems and the formation of regional and sub-regional networks. With these contextual changes, advances are currently being made in the production of semipublic goods that allow for cost-sharing or co-financing systems based on user contributions, increasing the possibilities of cooperation.

Martínez Nogueira (2002) considers that semipublic goods should be understood as those which, despite satisfying the criteria of free access associated with public goods, have at least one of two characteristics: (i) their use (usufruct) generates flows of strongly concentrated benefits; (ii) the transaction costs associated with the adaptation of users exceed the marginal cost of their provision by the suppliers of institutional technology services.

e) Global mechanisms, networks and programs

At the level of global mechanisms for innovation in agriculture, the current trend is to consolidate regional cooperation strategies, mechanisms and systems, in addition to supporting food security, rural development and environmental sustainability programs at the regional and national levels. With respect to the major institutional innovations achieved at this level, the literature highlights the consolidation of a new regulatory and institutional framework for international agricultural research; innovations in global, regional and national coordination and decision-making institutions; new models of agricultural development policies; and new mechanisms for funding and executing research.

According to Chaparro (2000), coordinated global action is fairly selective, since networks of subregional – or at most, of regional scope - have proven to be more efficient for research on natural and genetic resources, and for the management of agro-ecological systems. Some global-level programs and networks also have regional units, which are more effective. But even so, there are reasons and bases to support the use of global strategies to mobilize resources and knowledge, such as: (i) to facilitate the development of a critical mass of researchers in cutting-edge scientific areas, through strategic alliances between international centers, universities, innovation systems and production systems located in different regions; (ii) to promote the development of R&D networks aimed at generating learning and integration processes among the actors of rural development; and (iii) to develop synergies and economies of scale for technological research and development that provide support to *commodity chains* with global strategies of production and operation.

If new organizational structures are emerging that move in the direction of internationalization, a new regulatory and institutional framework for international agricultural research also should be negotiated and developed. This framework must absorb the changes in production and in the very nature of knowledge, together with the new opportunities for private ownership, and the changes in the role of the State and relations between the public and private sectors at the national, regional and international levels. Chaparro considers that this new regulatory framework is already being established, in response to a host of critical factors related to the generation and circulation of knowledge in the current world context and that we must build a Strategic Agenda for international agricultural research. The main critical factors are:

- Intellectual property rights applied to biological resources;
- Regulation of access to genetic resources and to the distribution of their benefits, together with Farmers' and Community Rights;
- Regulations on biosafety and management of genetically modified organisms (GMOs);
- Innovative mechanisms to finance agricultural research and regional cooperation;
- Sectoral policies for agricultural and rural development.

2.3 Synthesis and conclusion

The implementation of the development model for Latin America based on the internalization of the *economy of knowledge* depends on the strength of its institutions in producing learning and innovation to increase systemic competitiveness at national and regional levels.

Based on a review of the literature, this chapter presented a conceptual framework for institutional innovation with neo-institutionalist and neo-Schumpeterian contributions, to support the development of an analytical framework on institutional innovation in the area of agricultural research.

This is an effort to understand the role of institutions in the generation and dissemination of innovation and in the definition of institutional innovation in systems and networks. It links the trends and types of institutional innovation at each level of organization of agricultural research, according to a rationale in which the interfaces of each level are interactive, at many levels, between institutions, networks, systems and mechanisms. It identifies the links with infrastructure, trajectories, trends, mechanisms of interaction, coordination, governance and evolution and changes in the organizations, standard-setting and regulatory frameworks, or with research strategies, programs and projects.

The task of organizing a ST&I system includes the macro, meso and micro levels. At the meso- institutional level we find the contractual forms of organization between the micro and the macro levels. The art of managing ST&I systems is the art of combining competencies under different institutional situations.

With regard to the changes required to organize a ST&I system, Table 1 summarizes the current situation of R&D in agriculture at the micro, meso and macro levels.

The ST&I systems for agriculture in LAC are being managed in a way that is disconnected from the national ST&I systems. Therefore, beyond the recommendations, it is also necessary to think about ways to integrate agricultural institutions and innovations and connect these with the institutions, networks and innovative processes of the national systems.

Level	Current situation	Recommendation
Micro - internal to the organizations	Is most advanced: • Management efficiency • Operational efficacy • Effective results – demand x supply • Expansion of interfaces • Financial sustainability • Social and political legitimacy	Continue with modernization processes
Medium - Interfaces of the organizations	Is virtually ignored • Systems on paper • Cannibalism • Agro-centrism and NARI centrism • Exchange through "communicating vessels" • Absence of institutional governance systems	Need to make rapid progress
Macro – external to the organizations	Is virtually ignored • Monitoring of global regulation: trade in products and services; IP; health etc. • Laws to support innovation: facilitation of innovation process; promotion of public-private integration; definition of IP rules; develop systems integrate to the policies of development of the agribusiness. • Tax and parafiscal incentives for innovation • New contractual arrangements with the State • Expansion of competitive funds	Need to make rapid progress

Table 1 - Innovations at the micro, meso and macro levels of Agricultural R&D.

Chapter 3: Institutional Changes and Trends in Research and Innovation in LAC

The regionalization of research and innovation policies is aimed at furthering competitiveness and scientific and technological training, improving the response to environmental and social problems, and enhancing institutional models and concepts. Moreover, a regional innovation policy is a natural outcome of the ever-closer links between the countries in the region and their public and private institutions.

As Piñeiro *et al.* (1999) have noted, there is considerable similarity in the political and institutional characteristics of agricultural institutions in the Latin American countries, but there are also differences in organizational structure and management style that have to do with recent advances in each country in applying institutional reforms.

According to Ardila (1999), the institutions involved in agricultural research in Latin America suffer from five organizational problems in their organizational structure that must be overcome:

(i) the syndrome of "producing and not selling", a leftover from the supply-side model and the lack of interface mechanisms for linking the production and transfer of demand-driven knowledge;

(ii) the problem of the "centrifugal organization" of competencies, with the migration of researchers from public institutions to private firms in search of better remuneration;

(iii) the problem of administrative hypertrophy and the dilution of scientific excellence, so that administrators obtain more recognition than the scientists;

(iv) the "archipelago effect", which produces external and internal institutional isolation, and research groups that do not converge towards the general strategy of the organization; and

(v) the absence of social control and governance mechanisms for these institutions that allow for the participation of the users and funding bodies in setting priorities and other aspects of decision-making.

For Salles-Filho, Mello and Zackiewicz (2001), overcoming the distortions of the Latin American institutional framework is not a matter of striving for an optimal solution or a top-down policy. These problems are complex and should be approached cooperatively, with a view to devising and implementing solutions that guarantee the development of an innovative, interactive, and sustainable institutional environment. To achieve this, the authors recommend using *foresight* as a key tool to identify

institutional weaknesses and encourage participatory responses from stakeholders committed to institutional strengthening.

Research and innovation institutions in LAC have been the subject of studies by Ardila (2000), Salles-Filho *et al.* (2000a), and Lima (2005). The authors analyze several aspects of research organizations.

Ardila (2000) offers a retrospective of the institutional organization of agricultural research in the region. The author begins his analysis of this trajectory in the 1940s, when research and outreach programs linked to universities arose and experimental stations were created, subsequently giving rise to national agricultural research institutes (NARIs). The 1950s was the period when it was recognized that the region should develop its own capabilities to generate and adapt technologies. The process of establishing the NARIs, based on this new point of view, began in Argentina with INTA in 1956 and culminated in 1973 with the creation of Embrapa in Brazil. In fact, their histories are different, each one with its own specificities and determining factors but they arose around the same time, which confers a certain similarity to them.

In analyzing the current situation of the NARIs, Ardila confirms that a certain inertia persists, as shown by the following considerations: (i) they remain mainly focused on primary production and in some cases on basic commodities or food staples; (ii) the mandate of many NARIs limits them explicitly to working with small producers (ICTA in Guatemala, NARI in Peru, IBTA in Bolivia, CENTA in El Salvador); (iii) integration with universities, as in the cases of Mexico and the University of Chapingo, and Colombia and its National University, is rare; and (iv) the primary sector is largely absent from research activities. The author explains this situation by stating that agribusiness is often a small subsector with few possibilities of incorporating R&D to a significant degree. At the same time, he admits that the very concept of NARIs presupposes the production of technologies from the perspective of the public good.

One of the main problems faced by the countries of LAC concerns the research structure, which suffers from a variety of critical deficiencies – in areas such as infrastructure, the organizational model, and technical and administrative capacity – and that have a negative impact on the progress of research.

The study by Salles-Filho *et al.* (2000a) on provincial agricultural research organizations in Brazil offers a good illustration of these problems and has identified four groups of organizations with similar characteristics and three basic types of local institutions for agricultural innovation. The study also showed that the institutions were implementing the necessary changes and reorganization processes to achieve institutional transformation, and came to three important conclusions (see Table 2 below).

Groups of organizations with similar characteristics	**Group I** – Serious structural problems
	Group II – Course correction and adjustment of the institutional mission
	Group III – Modernization of the institutional apparatus
	Group IV – Institutional adjustments and organizational agility
Three basic types of institutions for agricultural innovation	**Type 1:** Organizations with training in a broader spectrum of the innovation process, acting simultaneously as codifiers and decodifiers within innovation networks
	Type 2: Lower level of vertical integration; training to act at the local and regional sphere from the perspective of typical problems of basic research and greater competence in adaptive research. In relation to the Type 1 institutions, these act more as decodifiers within innovation networks
	Type 3: Have internal capacity to codify typical regional and local problems, find solutions along with the networks to facilitate access by producers to known solutions– and may lead to research of greater depth among the network nodes that have the training to do so (Type 1 or 2 organizations).
Conclusions	i) No direct correlation between large institutions with a long tradition and improved organization
	ii) Even the well-established institutions need to improve their positioning within innovation networks
	iii) Institutions with better ranking enjoy greater support from provincial governments in terms of autonomy, flexibility, and awareness

Table 2 - Types of institutions involved in agricultural innovation.

Other conclusions of this study are that we face two types of tasks in the search for more active, effec-tively performing institutions that are better positioned in their political, socioeconomic, scientific and technological context. One of them is organizational adjustment stricto sensu; the other is the definition of the institution's role in agricultural research as a whole. The authors stress the importance of devel-oping networks, diversifying financial sources, linking research and users more closely, and searching for economies of scope and scale in research and multidisciplinary work.

Implementing institutional innovations becomes a necessary condition for reversing these problems and limitations. Silva and Cantou (2005) mention several institutional changes which, under the supervision of the relevant specialists, have been or should be implemented in LAC countries. The authors classify the changes according to whether they are aimed at research institutions or the public sector. The first groups involves a new institutional research model, the building of alliances aimed

at institutional innovation, the training of researchers in the new priority thematic areas, and the development of research and technology transfer programs. The changes aimed at the public sector include expanding the links between public and private institutions at the national, regional and international spheres, by thematic areas of interest, to optimize human, financial and infrastructural resources, as well as to encourage the development of specific bodies and roles, such as foundations and fund managers, to support the expansion of innovation.

Ardila (1999) indicates that the main transformations under way to improve the coordination and mobilization of national research capacity in LAC are: (i) the introduction of competitive funds, which increase the possibilities of mobilizing national capabilities and allocating resources for strategic and applied research; (ii) the organization of the national research system through the development of research networks and consortia to work on system projects; (iii) the implementation of changes to increase the participation of the private sector in financing agricultural research and outreach services; (iv) changes to improve the design, efficacy, and efficiency of the NARIs; (v) transformations to improve policy instruments and the setting of national priorities, and (vi) the improvement and streamlining of fundraising processes for R&D infrastructure.

Bearing in mind the context described above, and the objective of this study – that is, preparing a conceptual and practical framework for a strategic agenda for regional cooperation aimed at institutional innovations in the sphere of agricultural research – the approach proposed in this chapter follows the analytical framework proposed in Chapter 2.

As mentioned in Chapter 2, institutional innovations in national and regional organizations, networks and agricultural innovation systems encompass a comprehensive and complex set of actions including changes in the institutions themselves, as well as the introduction of new stakeholders, mechanisms, frameworks and institutional solutions aimed at integration, regulation, good governance and improved coordination among key players. Thus, the institutional changes to the systems and networks involve changes in the role of the State, new policies on innovation and intellectual property, funding and human resources, mechanisms for prospecting and disseminating technological information, technical, cooperation, and knowledge-transfer standardization programs, the establishment of research networks, and the creation of agencies or institutes (see item e of section 2.2). Since the main focus of this chapter is innovation in the agricultural research institutions of LAC and the detailed analysis of all the levels of aggregation are beyond the scope of this work, we have opted to analyze cases that are representative of the changes that have occurred and that reflect the alternatives for institutional innovation in the region.

The cases analyzed are divided into two types. Section 3.1 analyzes some institutional changes in developed countries described by Janssen (2002). Aside from referring to innovation models, it is crucial to understand the advances in these countries in order to draft effective innovation policies and strategic alliances with research institutions, universities, firms, networks, and the end markets of developed nations, with a view

to helping the NARIs and innovation systems of less developed countries to catch up technologically and institutionally.

Section 3.2 refers to innovations in Latin America, specifically two significant initiatives – Labex and RIPA[10]. These cases are considered strategic for analyzing the consolidation of the NARSs within LAC's regional system and also the hemispheric integration of the Americas for cooperation in agricultural research – this, given that global mechanisms are too restricted and regional or sub-regional action has been shown to be more efficient for agricultural research, as noted in section 2.2.

3.1 Institutional innovations: a few examples from beyond the region

Several countries have implemented institutional innovations in their agricultural research systems that may serve as reference points for LAC. Janssen's study (2002) of five industrialized countries shows the diversity of initiatives and the breadth of the changes that have had a significant impact on the funding and organization of research. As one of the conclusions of the paper argues, "The new research systems reflect the new conditions that society is imposing on agriculture, science and the management of the public sector." In essence, the changes in the systems of the countries studied present the following characteristics and trends:

a) Governance

- Reduction of *expenditures* through actions aimed at new public management styles, planning and accompaniment, and a review of the responsibilities of R&D firms.
- Involvement of the different *parties* interested in the decision-making process, as influenced by financial contributions.
- Flexibility in the management of human resources: adoption of more flexible mechanisms such as short-term contracts (doctorate projects), or a greater rotation of researchers. Disadvantages include reduced possibilities for long-term research. The advantages include a greater dissemination of the knowledge generated.

b) Funding

- Separation between funding and evaluation. Diversity of sources available through competitive funds.
- A co-funding model – by government and producers – which has not become very widespread. The tendency has been to assign to producers that which is of greatest interest to them.

[10] The case of the strategic training alliances of the Deep Waters Programs (PROCAP) of CENPES/ Petrobras, analyzed by Furtado Freitas (2000), or the cases of information technology training studied by Vonortas and Safioleas (1996), are two additional references of great importance to those considering strategies for technological and institutional innovation in the agriculture of less developed countries.

- Participation by the private sector. With the exception of Australia, in the rest of the countries studied private spending on research is greater than public spending.
- Development of competencies. Efforts are made to secure greater quality through competitive funds, mainly to conduct research on new topics that imply moving in new directions.

c) Execution of research

- Interaction with universities. Strengthening and consolidation of the integration between the education and research systems.
- Public-private research. Efforts to establish joint research mechanisms, programs or institutions. Emphasis on the joint generation of knowledge.
- International collaboration. Acknowledgement of the importance of this type of action. Participation by countries in regional forums. Initiatives to share research programs or research facilities.
- Legal frameworks. The development of legal frameworks for research is seen as essential for an effective research system.

Country	Rationale of the choice	Example of institutional innovation
United States	Most elaborate research system in the world. The country is the largest exporter of agricultural products	**Joint venture between Novartis and the University of California at Berkeley** - Type: Incremental - Level: NARS - Relevance: Partnership between the private sector and a university - Financing: Private and federal resources - Vulnerability: Criticism of exclusivity as a contractual condition (monopoly of scientific capacity)
Australia	Due to its relative isolation and agricultural exports	**Cooperative Research Centers** - Type: Radical innovation - Level: NARS and networks - Creation: 1991, by the federal government - Relevance: Improving the interaction between the public and private sectors, integrating researchers from both sectors, users of the agricultural sector, and other stakeholders. - Conduct: multidisciplinary, time-based and focusing on specific issues, centers for agricultural research, and natural resources - Funding: Government and other sources (competitive funds)
Switzerland	Being a small country, isolated from the large markets, and one that refused to join the European Community	**Research Institute for Organic Agriculture:** - Type: Radical innovation - Level: NARI, with impact on NARS - Creation: 1973, by a private foundation - Relevance: Recognition of the importance of harmonizing agriculture and the environment - Funding: Mostly from private sources. Government also helps. - Autonomy vis-à-vis the Government.
United Kingdom	Because of the changes in the organization of the public sector and its role in the generation of basic knowledge	**Basic research in universities** - Type: Incremental innovation - Level: NARS - Relevance: Increased participation by universities in agricultural research, especially basic research, considered as a public responsibility. - Impact: From 2.9% in 1961 to 14.7% in 1993. Recognition of the importance of basic research

Table 3 - Institutional innovations in research systems of industrialized countries

Table 3, above, summarizes the main characteristics and impacts of the innovations analyzed by Janssen (2002).

3.2 Institutional innovations in LAC

Institutional innovations in LAC during the 1990s affected the competencies and scope of the key players and their competitiveness within the NARIs, the networks and the national innovation systems. Experts claim that the institutional and organizational restructuring, the changes in management systems, in assets and competencies, and the institutional acquisition of greater efficiency, relevance and competitiveness within the prevailing context and in light of the need to protect the environment, all expanded the institutional possibilities and resources for regional cooperation. Most of the NARIs chose – or barely managed to – promote incremental institutional innovations: legal reforms, mission restatements, organizational and technological changes. In one case, the profound transformation of the institutional and organizational infrastructure has reestablished the institutional matrix in a life cycle.

A review of the literature suggests that the organizational model and institutional solutions applied to strengthen the competitiveness of the institutions has increased their administrative and financial autonomy, flexibility, agility, and capacity to detect and monitor trends. However, the significance of the changes and innovations calls for a broad evaluation. In any case, some institutional changes are particularly important as examples of innovation.

As shown in Figure 4, below, LAC countries have implemented institutional innovations at the level of the NARIs, networks and national and regional systems in line with the forecasts of change by different authors. It is worth noting that often an initiative transcends the limits originally envisioned, so that initiatives adopted at the NARI level can be seen reflected in the networks and/or the systems, and vice versa.

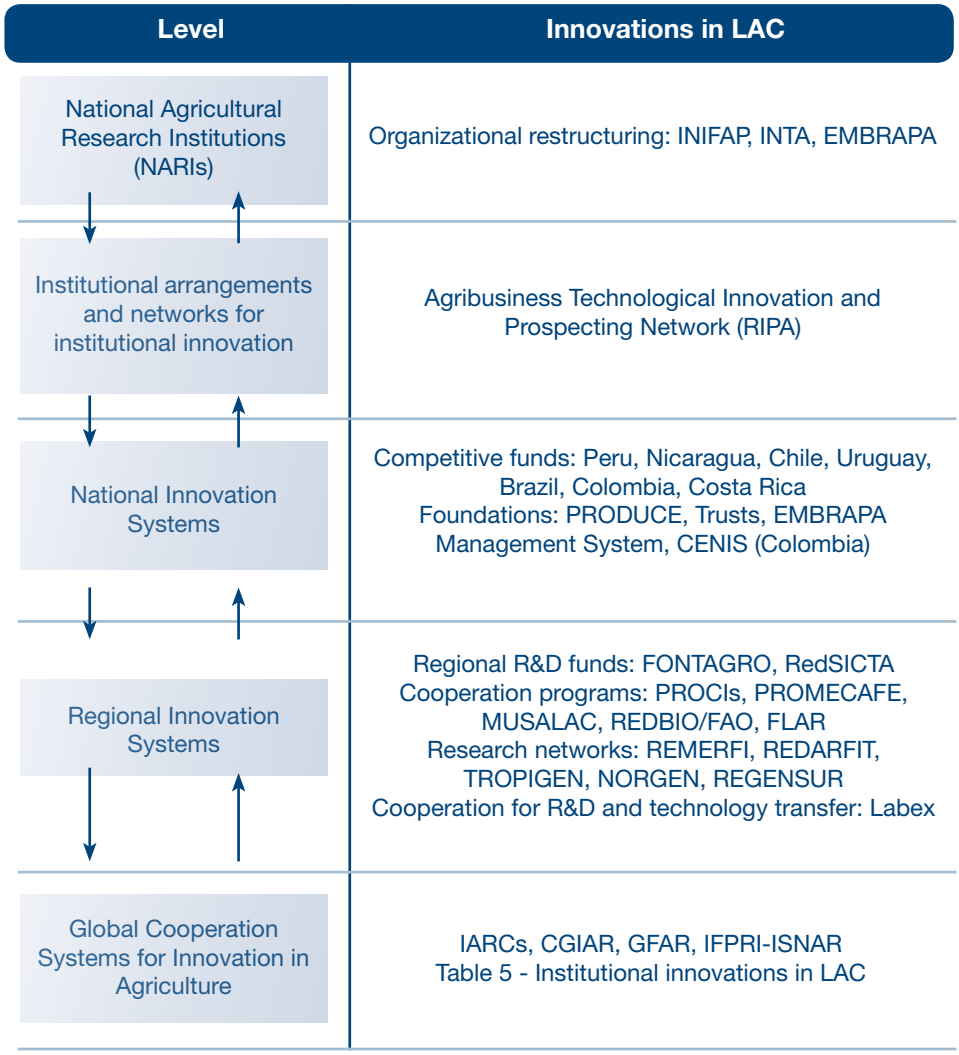

Table 5 - Institutional innovations in LAC

Figure 4 - Institutional innovations in LAC.

Scientific and technological cooperation at the local level

At the level of innovation networks and projects, special mention should be made of the *Agribusiness Technological Innovation and Prospecting Network (RIPA)*, which integrates various key players and sectors in order to meet the needs and demand for research.

Because of its characteristics, this initiative can contribute to the setting of priorities, strategic planning, and research scheduling through scenario building, prospective studies, economic evaluation of the alternatives, and interdisciplinary contributions.

RIPA is a project supported by the Ministry of Science and Technology of Brazil, through the Sectoral Agribusiness Fund, which is one of the funds for the promotion of science, technology and innovation in the country.

The Network has adopted as its mission the "Construction of the Agribusiness Technological Innovation and Prospecting Network (RIPA) with the creation of a collaborative environment that maximizes the channeling of the tacit and explicit knowledge of the organizations and encourages integrated actions between the institutions of the government, of the productive sector, of the third sector and of the ST&I community" (RIPA 2006).

With the initial objective of bringing together the key public and private players involved in the supply and demand of agribusiness technologies, RIPA includes among its members the following core institutions: the Brazilian Agribusiness Association (ABAC); the Brazilian Agricultural Research Company (Embrapa); the Foundation for Enhancing Industrial Research and Development (FIPAI); the Institute of Advances Studies (IEA); the Institute of Food Technology (ITAL) and Listen Local Information Systems LLC.

The goal of the Network is to rationalize research in Brazil and optimize the use of resources. With this in mind, RIPA intends to carry out advanced studies and support technological development and innovation in agribusiness processes and products. RIPA seeks to establish, from a systems perspective, future-oriented methodologies and experiences including reality monitoring, cooperative intelligence, competitive intelligence and knowledge management for strategic positioning vis-à-vis the opportunities and hazards confronting Brazilian agribusiness.

According to RIPA's vision, this can be achieved through the use of "a cooperative intelligence mechanism, increasingly used around the world, which aims to rationalize decisions and optimize the use of resources in research and development" (RIPA, 2006).

Scientific and technological cooperation at the regional level

At the regional level, special mention must be made of the PROCIs, cooperation programs created in the 1980s with the support of IICA and the IDB. These Programs have grown, incorporating a wide range of issues and becoming involved in initiatives for promoting the exchange of information and the establishment of alliances.

The cooperative programs are privileged elements in the implementation of regional policies. In fact, they even help to define these policies themselves, precisely because they are points of convergence that express the supply and demand of knowledge. Moreover, cooperative programs build up specific knowledge about where to locate and how to link competencies, how to identify regional priorities and how to devise cooperative projects involving a variety of key players. That is one of the main assets that a regional science and technology program should develop, particularly if it wishes to contribute to the growth of innovation systems.

Sá and Macedo (2005) review two critical factors involving one of these Programs, PROCITRÓPICOS, which could be applied to the others. The first concerns the need to maintain the institutional contributions from IICA and the member research institutes. The other factor is the key importance of forging institutional alliances

with other organizations - private, governmental and non-governmental - in order to achieve the expected outcomes.

Although the importance of those Programs is unquestionable, Ardila (2000) warns about the need to improve and modernize linkage mechanisms in order to increase their contribution to the solution of common problems in priority areas. For Ardila, there is a diversity of demands and a growing difficulty in setting priorities, which has made it so far impossible to integrate the research plans of the countries of the region within the framework of the PROCIs.

Scientific and technological cooperation across the hemisphere

An institutional innovation in the field of cooperation at the NARI level, and one that deserves greater attention as an alternative to be adopted by other countries, are the "Labex", which in Portuguese stands for "Laboratories Abroad" or "Virtual Laboratories". The Labex are an initiative of Embrapa for expanding and strengthening scientific and technological cooperation between Brazilian and foreign researchers (Embrapa 2006).

The first Laboratory was established in the United States[11] in 1998, in association between Embrapa and USDA (United States Department of Agriculture – Agricultural Research Service). In 2002, Embrapa set up Labex France, for interacting with Europe, and Brazil became the first developing country in the Southern hemisphere to have a virtual laboratory in Europe, in collaboration with centers of excellence in applied S&T on tropical agriculture. In the coming years, Embrapa will set up another laboratory, in Southern Asia, with the objective of promoting exchanges with Japan, China, and India.

According to Contini *et al*. (2004) three premises guided the establishment of the virtual laboratories abroad: (i) the growing importance of agribusiness for the development of Brazil; (ii) the growing consolidation of science and technology as determining factors for production and marketing; and (iii) the fact that the United States, Europe and Southern Asia are considered the three poles of knowledge generation in the world.

Since the development of Brazilian agribusiness depends on the country's capacity to incorporate new knowledge, the virtual laboratories are mechanisms through which the country can gain access to knowledge produced by developed nations. The purpose of the Labex is to engage in technological prospecting and institutional linkages. According to the presentation by Contini *et al*. (2004), the Laboratories have two main goals: "(a) to engage in cutting-edge research together with teams of excellence on issues of interest to Brazil; (b) to monitor science and technology, that is to say, to accompany the development of knowledge." The establishment of networks of researchers from the cooperating institutions and countries has been one of the strategies adopted by the Labex.

[11] Labex USA is located in Beltsville, and Labex France in Montpellier.

One of the features of the Labex is that their creation does not require new infrastructure, since the work is carried out in cooperation with institutions in other countries, hence the name "virtual laboratories". Contini *et al*. underscore the following advantages of the Labex: (i) they allow for low-cost and faster joint research involving overseas collaborators; (ii) they offer great flexibility both in launching and concluding activities in new areas; (iii) they contribute to integration, allowing the participation of Brazilian researchers in teams of excellence from other countries.

In Chapter 4, some guidelines are proposed for the design of a cooperation agenda on institutional innovation for research in agriculture. These guidelines are based on the current trends and challenges facing institutional innovation in ST&I, which are summarized below.

- Trends in institutional innovations in ST&I
  - Creation of a critical mass and a culture of innovation in strategic areas, encouraging the search for opportunities (internal or external);
  - Attraction of investment (internal or external);
  - Promotion of collective learning on management; and
  - Reduction of transaction costs.
- Challenges confronting institutional innovation in ST&I
  - Reducing inefficiencies, identifying opportunities and finding implementation paths;
  - Multiplying resources;
  - Exploiting economies of scale and scope;
  - Reducing uncertainties in the adoption of technologies.

Chapter 4: An Agenda for Cooperation

Cooperation in R&D and innovation activities aim to take advantage of and exploit economies of scale and scope. In striving for such economies, cooperation programs are essentially concerned with three issues: the elimination of sterile redundant efforts; the reduction of simultaneous but opposing approaches to the same issues; and the optimal use of existing synergies. Figure 5 below summarizes the consequences of not managing scale and scope economies effectively.

It must be admitted that redundant efforts should not always be eliminated. In S&T and R&D it is common for scientists to take paths that are uncertain and imprecise, and therefore a certain degree of redundancy is not totally bad. However, it is desirable that the redundant efforts be managed carefully, especially when resources are in short supply. Being profligate in S&T is not a problem if one enjoys abundant resources, but in cases of constraint the management of redundancy is practically an obligation. The same can be said about research in conflicting directions. For the same reason, conflicts of ideas and chosen paths are normal in S&T, but when the direction of work has more or less been defined, it makes little sense to continue wasting resources on opposing or divergent paths. Once again, this calls for the vigorous and proactive management of S&T and R&D. Regarding the final point, that of synergies, it is clear that failure to take advantage of these implies a grievous diseconomy of resources. Advances in S&T are mostly the result of the interaction of ideas. Economies of scope in S&T are perhaps the most self-evident.

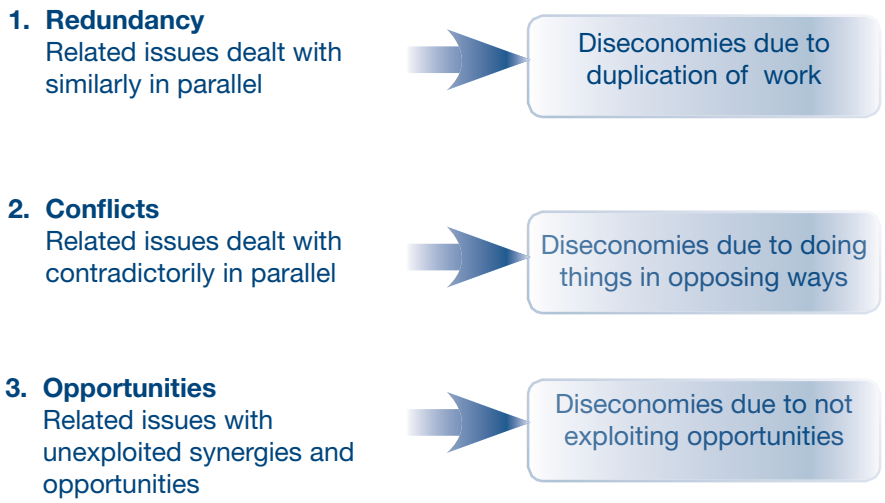

Figure 5- Diseconomies of scale and scope.

In complementary fashion, when the issue of innovation is introduced a fourth element must be added to the above: the management of the decision-making process. Innovation is the process of successfully introducing to the market new or

substantially improved products, processes, methods, or services (OECD 1993). If we accept this definition, then we cannot speak of innovation without adoption. The process is a single one: generation aimed at adoption. These are not separate processes, but part of a more complex procedure on which it is necessary to work actively. It is no longer tenable to work with separate concepts of generation, adoption and dissemination.

If the objective is to promote innovation, then "what to do" in R&D must be decided jointly with the stakeholders who will incorporate the "new" in their productive processes. This radically changes the conception and, therefore, the way of planning and implementing a research project. A very clear example is the "product roundtables" in the Uruguayan NARI, where there is shared responsibility for the design of R&D projects, which are in fact innovation projects.

Accordingly, the correct management of S&T and R&D can be summarized in three key points:

- The reduction of inefficiencies (through the reduction of redundant efforts and conflicting approaches);
- The promotion of opportunities through the synergic effect of economies of scale and scope; and
- The reduction of uncertainties related to the adoption of knowledge (whether a technology, a service, or a practice).

Cooperative work is one of most effective paths for achieving these three goals. First, because it makes it possible to eliminate or reduce redundant efforts and sterile conflicts (unnecessary for the progress of knowledge); second, because it allows a more effective use of networked economies; and third, because it includes the users and suppliers of knowledge within the same group, eliminating the classical dichotomy between the supply and demand for knowledge, which all too often creates a gap between research and innovation. The supply and demand for knowledge are part of the same process.

Given these facts, we can now look at the question of regional cooperation for R&D in *agribusiness*. The first thing to consider is that the primary form of regional cooperation is precisely the exchange of knowledge and information – in other words, cooperation through "communicating vessels" or, rather, the transfer of knowledge. This rationale led to the creation of the first Cooperative Agricultural Research Program (PROCI), PROCISUR. The changes spearheaded by PROCISUR in the late 1990s and early 2000s have been aimed at moving away from a "communicating vessels" approach toward one of promoting innovation. This has not been an easy task due to the lack of resources. Europe's regional cooperation policies – the most diversified and perhaps the most successful we are aware of – are fed by significant, and growing, budgets. Moreover, out of all the institutional apparatus created for this purpose by the European Commission, money has been the absolutely crucial factor in the promotion of regional S&T cooperation in the EU.

In LAC initiatives abound, more or less successful, but largely restricted by the relative lack of financial resources (it is not a matter of a lack of human resources, which we have in good quantity and quality). Regarding the institutional changes in LAC, we can consider two hypotheses: (i) micro-institutional changes are important but insufficient for achieving institutional sustainability and significantly enhancing the competitiveness of LAC agribusiness; and (ii) the lack of institutional innovation at the meso and macro level leads to the loss of competitiveness in agriculture for the following two reasons: (a) a growing remoteness from the frontiers of knowledge (and therefore from the capacity to play a leading role); and (b) increasing difficulties in taking advantage of economic and technological opportunities.

The key question then becomes how to make cooperation effective for agricultural S&T and innovation in LAC with limited financial resources. And there can be no other answer than to employ the resources available as *seed money* for leveraging more resources that may generate significant S&T and innovation. Otherwise, it will remain difficult to go beyond the transfer of information between countries and institutions (the "communicating vessels" approach).

From this perspective, four main issues must be considered:

a) The first issue is the expansion of cooperation potential. The cooperation model must not be restricted to the typical agricultural research institutions (especially the NARIs), particularly because they are the same ones, jointly with IICA and the IDB, that fund cooperation in agricultural R&D in LAC. On the contrary, the model must be multi-institutional and multinational. From this it follows that (i) any initiatives contemplated must seriously consider the participation of other types of institutions, including those representing other disciplines; and (ii) the initiatives must strive for cooperation with institutions from outside the region.

b) The second issue is the social ownership of knowledge through innovation (technological, organizational, service oriented, etc.). The cooperation model must definitively introduce a focus on "S&T + Innovation" (the model known as ST&I), meaning a conception of work effectively aimed at having an economic, social, and environmental impact rather than only focusing on S&T. Seeing things from this perspective leads to important changes in the very conception of a cooperative research project. Specifically, it means bringing into the research project the potential adopters, whether they be producers, associations of producers, agro-industries, or any other economic or political actor interested in the benefits that knowledge or technology is intended to generate.

c) The third issue is breaking away from the notion of cooperation aimed exclusively at the production of public goods. The cooperation model must be freed from the obsolete anchor of focusing only on work aimed at producing public goods. It almost contradicts the notion of innovation

itself. Of course, the problems of ownership and rivalry that define public goods and private goods are and will continue to be significant when it comes to cooperation contracts. However, nowadays the most important area of cooperation is found in the so called "club goods", where there are questions of ownership to be resolved but not of rivalry. Moreover, clubs are a way of creating interest among other actors than those exclusively in the public sector, thereby expanding the options implied in points (a) and (b) above.

d) The fourth point refers to the proactive search for opportunities. A regional cooperation model marked by lack of resources must aggressively explore opportunities for projects and activities wherever they may be found. This means that regional cooperation in LAC, before setting too many regulatory restrictions for itself, must first build up its "muscle tone" by searching and taking advantage of more robust projects and activities, particularly by applying the ST&I model.

The implementation of these ideas is not entirely new to some actors of the cooperation programs, but it is so to a significant number. Adoption is not a simple question of having the will. It calls for training in R&D and innovation management – clearly one of the first activities to be implemented as part of any cooperation program. For instance, working in innovation networks, clearly a step in the right direction of the contemporary ST&I model, calls for a type of management that is neither simple nor trivial. It also requires a process of R&D and innovation management training for the managers of the cooperation programs as well as for their main stakeholders.

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Abbreviations and acronyms used

CENTA	National Center for Agricultural and Forestry Technology
CGEE	Center for Strategic Studies Management
CGIAR	Consultative Group for International Agricultural Research
ECLAC	Economic Commission for Latin America and the Caribbean
EMBRAPA	Brazilian Agricultural Research Enterprise
EU-MERCOSUR	European Union – South American Common Market
FONTAGRO	Regional Fund for Agricultural Technology
FORAGRO	Forum of the Americas for Agricultural Research and Development
FTAA	Free Trade Area of the Americas
GFAR	Global Forum on Agricultural Research
IBTA	Bolivian Institute of Agricultural Technology
ICTA	Institute of Agricultural Science and Technology
IICA	Inter-American Institute for Cooperation on Agriculture
Labex	Laboratory Abroad or Virtual Laboratory
LAC	Latin America and the Caribbean
NARI	National Agricultural Research Institute
NARS	National Agricultural Research System
NGO	Non-Governmental Organization
PROCIs	Cooperative Agricultural Research Programs
R&D	Research and Development
SSIP	Sectoral Innovation and Production Systems
ST&I	Science, Technology and Innovation
TCE	Transaction Cost Economics
USA	United States of America
WTO	World Trade Organization

Annex A: Institutional innovations: Consolidated Table

Level	Trends	Institutional Innovations	Innovations in LAC
National Agricultural Research Institutions (NARIs)	Convergence, integration, administrative autonomy, flexibility and awareness, competitiveness in innovation system	Deregulation, decentralization, privatization, social control, reorganization of institutional infrastructure, administration, research and competencies management, cooperation, coordination with other stakeholders	Organizational restructuring: INIFAP, INTA, EMBRAPA
Institutional arrangements and networks for institutional innovation	Broadening dialogue and connectivity between institutions, circulation of competencies and exploitation of complementary assets	New institutional solution mechanisms and ways for technological cooperation and innovation, good governance and coordination among stakeholders to share inputs, standards, information, methodologies and equipment	Agribusiness Technological Innovation and Prospecting Network (RIPA)
National Innovation Systems	Overcoming of the lineal model, interaction of national capabilities, development of networks and consortia for systemic learning	Strengthening of institutions; new research mechanisms and models; new institutions, standards, regulatory frameworks, stakeholders, solutions and networks; new forms of organizational architecture, coordination and innovation management	Competitive funds: Peru, Nicaragua, Chile, Uruguay, Brazil, Colombia, Costa Rica Foundations: PRODUCE, Research Trusts, EMBRAPA Management System, CENIS (Colombia)
Regional Innovation Systems	Transformation of NARIs and NARSs to exploit the synergic effects of regional institutional diversity and joint financing capacity	New institutional solutions, organizations, networks and legal frameworks to take advantage of complementary strengths and convergences between the national systems; coordination to generate information, help in decision-making, fundraising, transfer of knowledge and training	Regional R&D funds: FONTAGRO, RedSICTA Cooperation programs: PROCIs, PROMECAFE, MUSALAC, REDBIO/FAO, FLAR Research networks: REMERFI, REDARFIT, TROPIGEN, NORGEN, REGENSUR Cooperation for R&D and technology transfer: Labex
Global Cooperation Systems for Innovation in Agriculture	Consolidation of regional research strategies and institutions; support for food security, rural development and environmental sustainability programs	New regulatory and institutional framework for agricultural research, innovation in global, regional and national liaison and decision-making bodies; new agricultural development policy models; and new funding mechanisms	IARCs, CGIAR, GFAR, IFPRI-ISNAR