



**INNOVATION TO ACHIEVE
COMPETITIVE, SUSTAINABLE
AND INCLUSIVE AGRICULTURE**

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INNOVATION TO ACHIEVE COMPETITIVE, SUSTAINABLE AND INCLUSIVE AGRICULTURE

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INTRODUCTION

Innovation is a fundamental tool to improve the productivity, efficacy and social, economic and environmental impact of the agrifood sector. At IICA, innovation has been defined as:

The application of new knowledge to productive or organizational processes. It comes about when society takes ownership of knowledge, ideas, practices and technologies, translating them into a change that is useful and beneficial in productive or organizational life. A novel idea implemented in a particular way can be considered an innovation if it is new in the context, even though it may not be new to the world¹.

Innovation is one of the main tools to overcome the challenges of the agrifood system at the global, hemispheric, regional and national levels. Experience has shown that innovation decisively contributes to increasing productivity. The growing demand for food relies upon innovation not only to obtain more and better food, but also

¹ IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica). 2014. Innovation in Agriculture: A Key Process for Sustainable Development. San José, Costa Rica. p. 1.

to produce it sustainably. Innovation also contributes to bridging the gap between developing and more advanced countries, regions and productive sectors, allowing the more challenged areas to become more competitive and efficient. Innovation also allows small-sized and family farmers to link primary production with the processing, packaging and trading stages, which translates into better opportunities and income for more people in rural sectors facing the most difficult challenges.

Furthermore, a more sustainable agriculture can be achieved through innovation, becoming a key factor to mitigate and reverse the effects of climate change, one of the greatest challenges faced by humanity and in which agriculture has a preponderant role. Another difficult challenge is the issue of poverty, which hinders progress, causes marginalization and inequality for the majority of the world's population, and which is mostly concentrated in rural areas. Innovation represents a way for families to overcome poverty by engaging in a more efficient, productive agriculture.

Finally, innovation is key in achieving food security, one of the main objectives of agriculture for the 21st century. The agriculture of the future must be able to supply sufficient food that is healthy, nutritious and safe to a population expected to reach 9.6 billion people by 2050. This can only be possible through innovation, the use of new technologies, studies and research closely linked to production and consumers' needs, and a coordinated participation between the public and the private sectors, farmers, consumers, academics, researchers and international cooperation organizations.

The Institute had the honor of hosting the Meeting of Ministers of Agriculture of the Americas in 2011, with the motto "Sowing innovation to harvest prosperity". The meeting allowed Member States to define a roadmap to promote innovation in agriculture. The Ministerial Declaration is a reflection of this spirit of utmost dedication to meet this goal.

IICA has developed this book, Innovation to achieve competitive, sustainable and inclusive agriculture with the purpose of offering member countries, governments, farmers and stakeholders in the continent an overview of this central issue for the agricultural sector. The document explains the importance of agricultural innovation and the way in which IICA has addressed and developed, based on the guidelines

defined by the Heads of State and the Ministers of Agriculture of the Americas, the actions included in the strategic plan and the medium-term plans.

More specifically, this book discusses innovation problems and opportunities for family farming in the different regions of the American continent, as well as the role of hemispheric, regional and national agrifood research systems. Likewise, it provides a description of the main innovation actions and projects promoted by IICA, and the main success cases over recent years. I am confident that this document will be useful for all of those interested in knowing about the evolution of innovation in agriculture in the Americas.

Dr. Víctor M. Villalobos
Director General
IICA

THE IMPORTANCE OF INNOVATION

Innovation plays a key role in improving the productivity of the agrifood sector. In the words of the United Nations Food and Agriculture Organization (FAO), "agricultural innovation is a process through which a person or organization introduces the use of new or existing products, processes or forms of organization into society or the economy, with the goal of increasing efficacy, competitiveness, resilience in the face of a crisis, or environmental sustainability, thus helping achieve food and nutritional security, economic development and the sustainable management of natural resources" (FAO 2015 a:5).

This same organization also states that "innovation takes place when new ideas, technologies or processes are adopted both individually and collectively. If these ideas are successful, then they are disseminated throughout communities and societies. The process is complex, many stakeholders intervene and it cannot work on its own. It must be driven by an effective *innovation system*. An agricultural innovation system comprises, among other things, the appropriate institutional and economic environment needed by all farmers. Other key components are research, advisory services and efficient

farmers' organizations. Innovation is often based on local knowledge and traditional systems, which are adapted in combination with new sources of knowledge stemming from formal research systems" (FAO 2015a:xii).

Innovation also "presupposes an ability to innovate at an individual, collective, national and international level". For this reason, farmers, extensionists, researchers and all stakeholders of agricultural innovation systems must be educated and trained so that they can become more knowledgeable and qualified. Special attention must be paid to women and young farmers, particularly in family farming. On the other hand, the capacity for collective innovation relies upon the existence of networks that can promote said capacity; it is in this sense that cooperatives and farmers' organizations play a key role. Finally, "the environment and incentives for innovation depend on a good public administration and sound economic policies, adequate property rights, market infrastructure, and a suitable regulatory framework" (FAO 2015a:xii).

The World Bank considers innovation as the process through which individuals or organizations dominate and implement the design and production of goods and services that are new to them, whether they are new to their competitors, their country or the world. It also defines an innovation system as a network of organizations, companies and individuals seeking to develop new products, processes and forms of organization to profit from them economically, while simultaneously developing institutions and policies that affect their behavior and execution (World Bank 2012:2).

The Organization for Economic Cooperation and Development (OECD), on the other hand, adopts the definition of innovation coined by the Oslo Manual, which states that innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations. In this sense, it considers four types of innovation:

➔ *Product innovation*: introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components

and materials, incorporated software, user friendliness or other functional characteristics.

- ➔ *Process innovation*: implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software or all of the above.
- ➔ *Marketing innovation*: implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.
- ➔ *Organizational innovation*: implementation of a new organizational method in the firm's business practices, workplace organization or external relations.
- ➔ Innovation can refer to one single significant change or a series of small changes which together represent a big change. Still, all innovations entail a certain degree of novelty, and it may be something new for the company, for the market or the world (OECD 2013:12).

In the words of the World Bank:

Agricultural development requires and relies upon innovation and innovation systems. Innovation is widely recognized as an important source of improvement in productivity, competitiveness and economic growth, in both advanced and emerging economies. Innovation also plays a key role in job creation, income generation, poverty eradication and the promotion of social development (OECD, cited in World Bank 2012:2).

The Inter-American Institute for Cooperation on Agriculture (IICA), on the other hand, points out that innovation is:

The application of new knowledge to productive or organizational processes. It comes about when society takes ownership of knowledge, ideas, practices and technologies, translating them into a change that is useful and beneficial in productive or organizational life. A novel idea implemented in a particular way can be considered an innovation if it is new in the context, even though it may not be new to the world (French et al. 2014:1).

Using the OECD's definition as a basis, the Institute defines innovation as:

"[...] The implementation of a novelty or improvement (technological or non-technological) of a product (good or service), process, new marketing method or new organizational method.

"[The] application of ideas, knowledge or novel practices for a particular context, with the purpose of creating positive changes that can satisfy needs, face challenges or seize opportunities".

These are, therefore, "novelties and useful changes that may be substantial (a major change or improvement) or cumulative (small changes that as a whole result in a significant improvement)" (French *et al.* 2014:1).

Innovation therefore seeks to solve problems more than create a new technology or product. In many cases, it is about changing the way in which things are done (Table 1):

TABLE 1. Methods and instruments for sustainable productivity growth in agriculture.

METHOD	TYPES OF INSTRUMENTS
Creation, adaptation and application of new technologies and practices	<ul style="list-style-type: none"> » Improvements in technologies and practices, carried out by farmers themselves. » Formalized scientific research and development. » Combination of improvements carried out by farmers themselves and formalized scientific research and development.
Acceleration and increased adoption of existing technologies and practices	<ul style="list-style-type: none"> » Addressing economic limitations to adopt technologies and practices. » Extension and advisory services (public and private). » Promotion of innovation capacities. » Individually (education, training). » Collectively (including farmers' organizations and cooperatives). » Suitable environment for innovation (including associations and networks).

Source: FAO 2015a:4.

Innovation and agricultural development

Agricultural development requires a good capacity for adaptation and response. These qualities become most relevant when facing events such as price fluctuations in international markets and climate change.

Other factors that affect agricultural development are technological advances and institutional transformations, as well as the role of the State, the private sector and the civil society. The World Bank has strongly emphasized the fact that "in this context, markets, urbanization, globalization and a changing environment not only affect consumption, competition and trade patterns, but also drive agricultural development and innovation more than ever before" (World Bank 2012:3).

In this scenario, innovation appears as a fundamental tool for agriculture to face the aforementioned challenges. However, in order to promote innovation, it is necessary for governments to invest in research and development (R+D), extension and education.

Furthermore, "innovation requires a more interactive, dynamic and flexible process, in which the key players deal with many complementary conditions and activities that go beyond traditional research, development and extension" (OECD 2013:15).

Agricultural innovation is the result of an interaction between the different stakeholders of the sector: farmers, processors, packers, distributors and consumers. Or, as stated by the World Bank (2012:3), it often stems from collective action, coordination and knowledge exchange between different stakeholders, as observed in Figure 1.

Undoubtedly, agricultural research and development translates into an increase in productivity, and the application of sustainable technologies and productive practices also leads to a more sustainable use of natural resources.

A wide range of stakeholders create, transfer and adopt innovations; a second group informs farmers and the public on these advances. The role of the government is to serve as a guide and promote research by strengthening its supporting infrastructure.

An agricultural innovation system

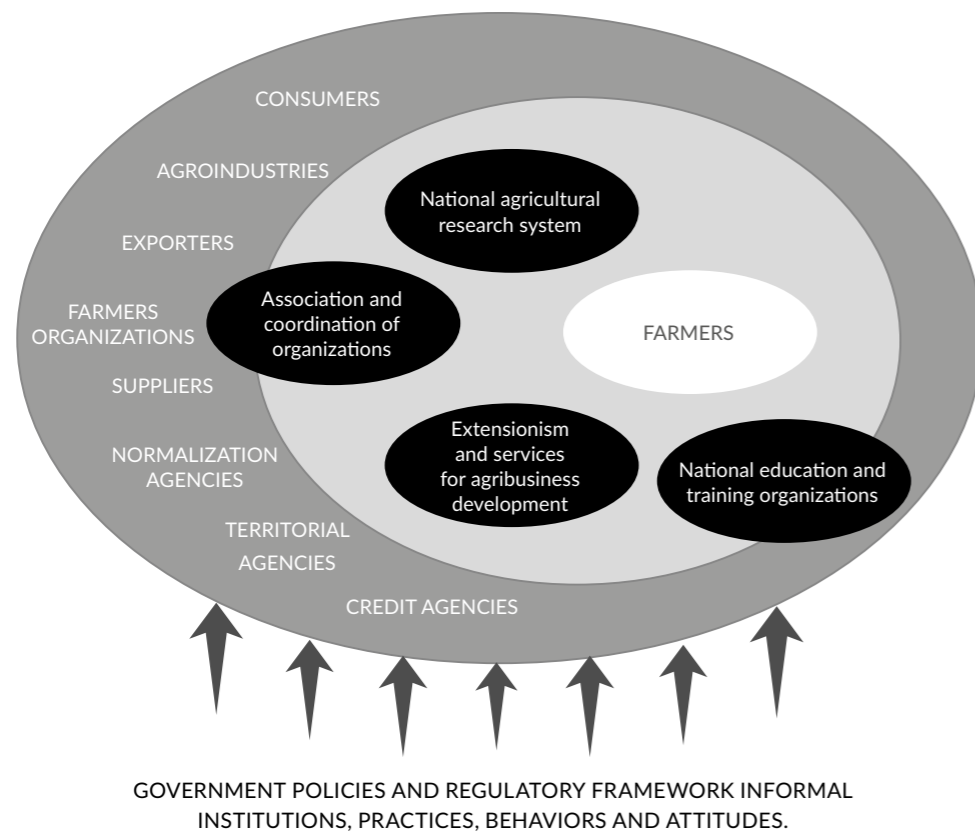


FIGURE 1. An agricultural innovation system.

Source: World Bank 2012:4.

Undoubtedly, public policies and regulations influence the business and innovation environment. Private research and farmers create innovations. The different institutions and organizations help communicate these advances and obtain funds to finance them. Market and consumers' behavior are a clear indication of where the demand for innovation is and its level of acceptance (OECD 2013:15).

Innovation is essential to increase agricultural productivity, and is the key element to strengthen competitiveness and economic growth. It helps farmers increase their

income, as long as it is applied with continuity. It also helps produce more and better food, more and better raw material, and can do this without harming the environment and adapting to climate change.

One must not forget that “innovation in the food industry is mostly based on changes in food consumption habits associated with higher income, health problems, higher participation of women in the workforce and less available time for meals” (OECD 2013:15).

But more importantly, it must be noted that in recent years the concept of innovation in agriculture has evolved. It is no longer defined as the adoption of new technologies. According to Sonnino and Ruanne (2013:34-35), it is more about “a successful combination of technologies and practices, new knowledge and mental structures, and new institutions and forms of social organization”. Let us examine the drivers of innovation according to these authors (Table 2):

TABLE 2. Drivers of innovation in agriculture.

SECTORS	FACTORS THAT STIMULATE INNOVATION
Market	<ul style="list-style-type: none"> » Changes in food consumption patterns as a result of the growth of the middle class. » Dominating position of food distribution chains. » International trade and changes in global demand. » Changes in consumer's awareness on issues such as sustainability, food safety, etc. » Price of inputs and labor costs.
Environment	<ul style="list-style-type: none"> » Climate change. » Natural disasters. » Availability of natural resources.
Policies and regulatory frameworks	<ul style="list-style-type: none"> » Rules, standards and norms. » Taxes and fees. » Incentives and subsidies.
Science and technology	<ul style="list-style-type: none"> » Advances in basic knowledge on life sciences. » ICT-based technologies. » Information on market opportunities and prices. » Availability of new inputs. » Availability of new agricultural practices. » New storage and conservation technologies and infrastructure.

Source: Sonnino y Ruane 2013:35.

Based on this chart, it becomes clear that agricultural innovation systems not only rely upon scientific and technological progress, but also on institutional and organizational innovation. This process requires combined efforts and the involvement of the research, education and extension sectors, as well as the participation of farmers, public policymakers, regulatory agencies, non-governmental organizations, consumers and distributors.

Although innovation is key for economic development, the hardships endured by many productive branches, including agriculture, and the insufficient government funds, has hindered its expansion. Therefore, it is important to pay special attention to analyzing the cost-benefit ratio, in order to establish clear priorities and avoid the duplication of efforts, a frequent problem in the agricultural sector.

It is not easy to measure innovation, because it involves a complex, continuous process. However, it is necessary to establish certain parameters to evaluate the effectiveness of policies, contrasting them with the set objectives (Sonnino and Ruane, 2013:16). The OECD and the European Office of Statistics (Eurostat) developed a classification of agricultural innovation based on the Frascati Manual (OECD 2015), in which agricultural production and technology include research on agriculture, forestry, fisheries and food production, which in turn contain research on chemical fertilizers, biocides, biological pest control, mechanization of agriculture, the impact of agriculture and forestry on the environment, and research for food production and technology development.

The input indicators measure the investment on innovation (for example, how much was spent on research and development, number of persons involved), whilst output indicators focus on how much was spent on academic publications, number of registered patents, number of created databases and software, and the number of innovations created and introduced into companies. As of yet, there are no systematic measurements of the impact of innovation on the economy or the impact of public policies that favor innovation.

The Agricultural Science and Technology Indicators Program (ASTI) is a source of data, available for any interested party, on existing agricultural innovation systems in

developing countries. Under the leadership of the International Food Policy Research Institute (IFPRI), and as part of the CGIAR Research Program on Policies, Institutions and Markets (PIM), ASTI works together with a wide network of local collaborators to compile, gather and publish data on human, financial and institutional research at the national and regional levels, as well as in governmental organizations, higher education institutions, non-profit organizations and, whenever possible, for-profit private agricultural research organizations.

Undoubtedly, the extent of agricultural research's contribution to agricultural growth can never be fully understood without quantitative information. Indicators extracted from this type of data help measure, monitor and compare the input of agricultural innovation systems. The ASTI plays a key role by supplying information that helps better understand the current status of national agricultural research systems in developing countries (ASTI *et al.* s.f.).

The government's role in innovation

Agricultural and environmental policies, as well as programs regulating the use of soil and water, affect the development of agricultural innovation systems. A clear government innovation policy involves investing in public science and development institutions, and supporting the private sector through tax exemption policies and financial support to public-private projects, as well as promoting the development of information and communication technologies, infrastructure for biological sciences and information systems, and intellectual property rights. This type of policy also fosters the creation and development of networks, centers of excellence and platforms that promote collaborative work concerning these issues.

By doing this, public research and agricultural development policies seek to address these challenges faced by the agrifood sector. Research and development generate technologies, while extensionists and consulting services work to help farmers adopt said technologies. Still, the private sector must generate innovation and foster its adoption, because without public-private synergies, improving the efficacy and development of innovation systems will become extremely difficult.

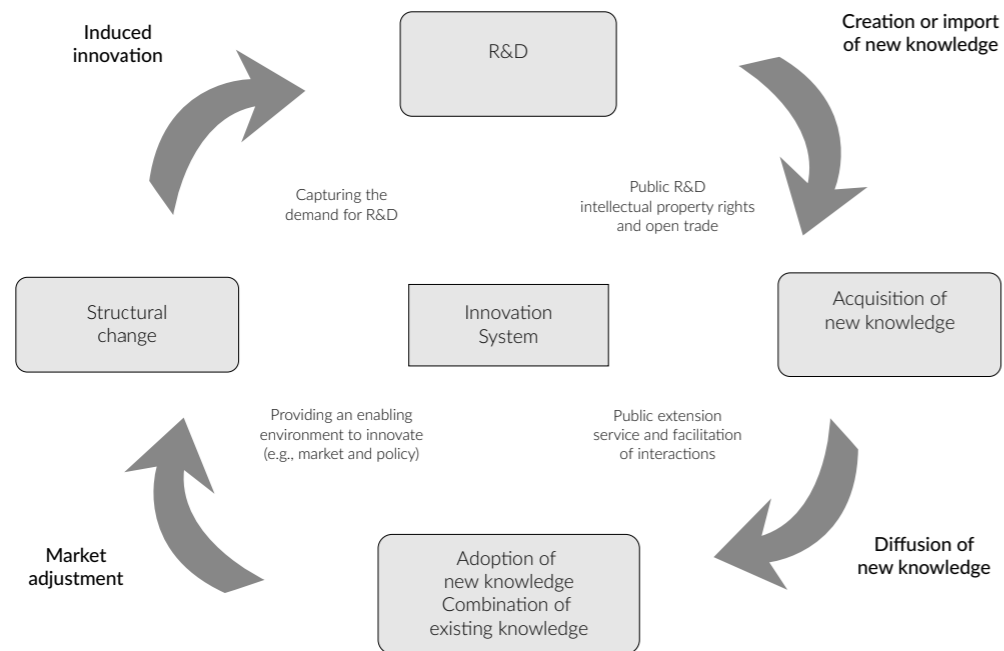


FIGURE 2. An illustration of the innovation dynamics in agriculture.

Source: OECD 2013:17.

The OECD (2013:18) has proposed an innovation strategy based on the following principles:

1. Empowering people to innovate

- ➔ Education and training systems should equip people with the foundations to learn and develop the broad range of skills needed for innovation in all its forms, and with the flexibility to upgrade skills and adapt to changing market conditions, to foster an innovative workplace, and ensure that employment policies facilitate efficient organizational change.
- ➔ Enable consumers to be active participants in the innovation process.
- ➔ Foster an entrepreneurial culture by instilling the skills and attitudes needed for creative enterprises.

2. Unleashing innovations

- ➔ Ensure that framework conditions are sound and supportive of competition, conducive to innovation and mutually reinforcing.
- ➔ Mobilize private funding for innovation by fostering well-functioning financial markets and easing access to finance for new firms, in particular for the early stages of innovation. Encourage the diffusion of best practices in the reporting of intangible investments and develop market-friendly approaches to support innovation.
- ➔ Foster open markets, a competitive and dynamic business sector, and a culture of healthy risk taking and creative activity. Foster innovation in small- and medium-sized firms, in particular those that are new or at an early development stage.

3. Creating and applying knowledge

- ➔ Provide sufficient investment in an effective public research system and improve the governance of research institutions. Ensure coherence between multi-level sources of funding for R&D.
- ➔ Ensure coherence between multi-level sources of funding for R&D. Ensure that a modern and reliable knowledge infrastructure that supports innovation is in place, accompanied by the regulatory frameworks which support open access to networks and competition in the market. Create a suitable policy and regulatory environment that allows for the responsible development of technologies and their convergence.
- ➔ Facilitate efficient knowledge flows and foster the development of networks and markets which enable the creation, circulation and diffusion of knowledge, along with an effective system of intellectual property rights.
- ➔ Foster innovation in the public sector at all levels of government to enhance the delivery of public services, improve efficiency, coverage and equity, and create positive externalities in the rest of the economy.

4. Applying innovation to address global and social challenges

- ➔ Improve international scientific and technological co-operation and technology transfer, including through the development of international mechanisms to finance innovation and share costs.

- ➔ Provide a predictable policy regime which provides flexibility and incentives to address global challenges through innovation in developed and developing countries, and encourages invention and the adoption of cost-effective technologies.
- ➔ To spur innovation as a tool for development, strengthen the foundations for innovation in low-income countries, including affordable access to modern technologies. Foster entrepreneurship throughout the economy, and enable entrepreneurs to experiment, invest and expand creative economic activities, particularly around agriculture.

5. Improving the governance and measurement of policies for innovation

- ➔ Ensure policy coherence by treating innovation as a central component of government policy, with strong leadership at the highest political levels. Enable regional and local stakeholders to foster innovation, while ensuring co-ordination across regions and with national efforts. Foster evidence-based decision-making and policy accountability by recognizing measurement as central to the innovation agenda.

Innovation development is closely associated to a solid science and technology system. In other words, without knowledge –knowledge created both at the national and local levels– innovation can never grow. Food production, and as a result, poverty eradication and the well-being of rural families, relies to a great extent upon knowledge generation and application.

Institutional restrictions (and not only budgetary ones) can also hinder the development of public research organizations. These restrictions are caused by the dependency that many public research organizations have regarding institutional development, a lack of consensus on strategic visions, absence of leadership, poor management and the prioritization of national research structures over the creation of partnerships. Another influential factor is the loss of qualified scientists and the absence of associations between the different stakeholders of innovation (World Bank 2012:5).

Research organizations have attempted to find a solution for these limitations by paying more attention to management activities –planning, financial management,

relevant programs for clients, etc. –than to improving the physical infrastructure, acquiring new equipment, developing human resources or looking for operative funds.

According to the World Bank, public investment in science, technology and agricultural development has increased significantly in the past years, going from 16 billion dollars in 1981 to 23 billion dollars in 2005. However, these investments were mostly concentrated in just a few countries.

Governments are the entities that make the most significant contribution to agriculture, accounting for nearly 81 % of the total investment; 7 % comes from donors; and another 7 % from contractual arrangements between public and private companies.

The private sector, on the other hand, spent about 16 billion dollars on agricultural research in 2005, equivalent to 41 % of the total investment in this field, including government expenditure. Most of the private investments are made by companies conducting agricultural research in high-income countries.

The World Bank is one of the top institutions when it comes to promoting investments in research and development to improve agricultural productivity and boost innovation. Between 1990 and 2010, it invested 4.9 billion dollars in agricultural research and development and consultancy services. The annual commitments of the World Bank in terms of agricultural research, extension, education and training represent between 100 and 800 million dollars (World Bank 2012:5).

The bank has also dedicated its utmost efforts to increasing the participation of clients and financing and developing more pluralistic agricultural information and knowledge systems (Table 3):

TABLE 3. Defining Features of the Three Main Frameworks Used to Promote and Invest in Knowledge in the Agriculture Sector.

Defining feature	National agricultural research systems	Agricultural knowledge and information systems	Agricultural innovation systems
Stakeholders	Research organizations	Farmer, research, extension, and education	Wide spectrum of stakeholders

TABLE 3. Continuation...

Outcome	Technology invention and transfer	Technology adoption and innovation	Different types of innovation
Organizing principle	Using science to create new technologies	Accessing agricultural knowledge	New uses of knowledge for social and economic change
Mechanism for innovation	Technology transfer	Knowledge and information exchange	Interaction and innovation among stakeholders
Role of policy	Resource allocation, priority setting	Linking research, extension, and education	Enabling innovation
Nature of capacity strengthening	Strengthening infrastructure and human resources	Strengthening communication between stakeholders in rural areas	Strengthening interactions between all stakeholders; creating an enabling environment for innovation.

Source: World Bank 2012:6.

Below are some of the changes implemented in research and agricultural extension organizations, according to the World Bank (Box 1):

BOX 1. Recent reforms in agricultural research and public extension.

- *Increasing the participation of farmers, the private sector, and other stakeholders in research governing boards and advisory panels to attain real influence over research decisions and priorities. The participation of women farmers is particularly important, given their crucial role in rural production systems, the special constraints under which they operate (for example, time constraints), and their range of activities and enterprises, including marketing, processing, and food storage.*

- *Decentralizing research to bring scientists closer to clients and better focus research on local problems and opportunities.*
- *Decentralizing extension services to improve accountability to local users and facilitate clients' "purchase" of research services and products that respond better to their needs. Matching-grant programs for farmer and community groups allow them to test and disseminate new technologies.*
- *Establishing competitive funding mechanisms that involve key stakeholders, especially users, in promoting demand-driven research, setting priorities, formulating projects, and screening proposals. Competitive funds have increased the role of universities in agricultural R&D in some countries. Continuing challenges include limited engagement with the private sector, sustainability of funding, the bias against strategic R&D, and the heavy transaction costs.*
- *Promoting producer organizations to reach economies of scale in services and market activities, increase farmers' ability to demand better services, and help producers to hold service providers accountable.*
- *Mixing public and private systems by enabling farmer organizations, NGOs, and public agencies to outsource advisory services, identify the "best fit" for the particular job, and recognize the private-good attributes of some extension services. For example, approaches based on public funding that involve local governments, the private sector, NGOs, and producer organizations in extension service delivery may be most relevant to subsistence farmers, whereas various forms of private co-financing may be appropriate for commercial agriculture, extending to full privatization for some services.*

Source: World Bank 2012:6.

Agricultural extension and advisory services have passed through cycles of challenge and reform in recent years. The public services that dominate extension services are plagued by widespread problems: limited funding, insufficient technology, poorly trained staff, weak links to research, and limited farmer participation. Organizations have attempted to overcome these difficulties by decentralizing extension and advisory services and promote the association between research and farmers. In recent years, more attention has been paid to the needs of women and youth, and to facilitate the integration of farmers into markets.

Despite widespread agreement on the need for change, it is clear that no single extension model is universally relevant. New models need to be developed, based on analyses of the specific farming systems and social conditions they are expected to

address. The ever-growing role of information and communication technologies (ICT) in producing and disseminating knowledge offers striking opportunities to change how agricultural science, innovation, and development occur by enabling a variety of stakeholders to interact and collaborate in new ways to enhance the innovation process.

Without agricultural education or training, countries will find it very difficult to innovate. Furthermore, it is no secret that these activities have experienced serious difficulties in recent years. The lack of synchrony with the reality of markets has been accompanied by a dramatic reduction of government investments and funds to support agricultural education and training. Experience has shown, however, that it is possible to build productive and financially sustainable education systems. Such is the case of developed countries like Denmark, Japan, the Netherlands, and the United States, or developing countries such as India, Malaysia, Brazil, and the Philippines (World Bank 2012:17).

Investing in science and technology is today essential to maintain and improve agricultural productivity. Unfortunately, efforts dedicated to strengthening research systems and increasing the availability of knowledge has yet to translate into an increase in innovation or a broader application of knowledge in agriculture.

The World Bank has pointed out that for innovation to take place, effective bridging mechanisms are often needed to facilitate communication, “translation” (of information), and mediation across the boundaries among the various stakeholders in agricultural research and development and between knowledge and action.

Such facilitating and bridging mechanisms can include diverse innovation coordination mechanisms such as networks, associations, and extension services, but also information and communication technologies. Indeed, ICTs offer the opportunity to improve knowledge flows among knowledge producers, disseminators, and users and, for example, among network partners. In other words, they support the opening up of the research processes to interaction and more accessible knowledge use, and widen the participation of stakeholders in the innovation and governance process. ICTs have more often been associated with providing advanced services to number crunching and data management, geospatial applications, knowledge-based

systems and robotics, and improved farm equipment and processes, but less often been considered for connecting diverse innovation communities—whether at the local, subsectoral, and national levels.

The World Bank considers that ICTs that serve as information collectors, analyzers, sharers and disseminators are already positively affecting agricultural interventions in developing countries. Affordable mobile applications, in particular, provide linkages to previously isolated stakeholders: information on prices, good farming practices, soil fertility, pest or disease outbreaks, and extreme weather has expanded farmers’ opportunities to capitalize on markets, react to unfavorable agricultural conditions more effectively, and better interact with public service agents.

Satellite imagery and aerial photography have also increased the capacity of scientists, researchers, and even insurance providers to study farm conditions in remote areas and assess damage from climatic challenges like drought. Technologies like radio frequency identification “tags” and other wireless devices are improving livestock management, allowing producers to monitor animal health and trace animal products through the supply chain. A persistent barrier to innovation, the lack of rural finance, is also lifted by digital tools. (World Bank 2012:8).

What conditions are favorable to innovation?

According to IICA:

Innovation in agriculture and rural development, like in other sectors, takes place in a given socioeconomic context and reacts to the presence (or absence) of favorable conditions, including most particularly, sufficient domestic development, institutional and regulatory frameworks, a reservoir of knowledge and human skills, a society that is calling out for innovation, and a welcoming regional and global environment.

Likewise, certain interactions and associations condition innovation processes. These processes are usually the result of different triggers that can be market-related, or technological, political and environmental. Regardless of their type, they all require the presence of favorable conditions for innovation, where the

government (from different sectors, ministries and institutions) plays a key role (French et al. 2014:11).

For IICA, creating public policies that are able to eliminate market distortions are a fundamental tool to promote innovation, support science and technology, protect intellectual property and facilitate access to technical and financial services.

Equally important is the involvement of the private sector. For this reason, IICA has promoted a strategy to work closely with this sector to create a favorable environment for investments and the generation of technologies, which in turn can increase the productivity, competitiveness and sustainability of the agricultural sector throughout the continent.

The articulation between the stakeholders of agricultural innovation systems (farmers, providers of technical or financial services, and of inputs, public and private research institutions and extension services) is fundamental. Figure 3 shows the interactions between these elements.

Innovation and the main contemporary challenges

Humanity is currently facing many challenges, and agricultural issues are among the most relevant. Food security appears at the top of the list. Malnutrition and all the problems associated with it are concentrated in the most underdeveloped countries (the so-called emerging countries). According to FAO estimations in 2010² 98 % of the 925 million people suffering from malnutrition in the world live in these countries, mainly (two-thirds of them) in Bangladesh, China, Democratic Republic of Congo, India, Indonesia and Pakistan.

Increasing the availability of food, improving accessibility (enabling access to food for people in need), using food adequately and having solid systems are all crucial steps in achieving food security.

2 FAO (Food and Agriculture Organization of the United Nations, Italy). 2010. The State of Food Insecurity in the World. Rome, Italy, p. 13. Available at <http://www.fao.org/docrep/013/i1683s/i1683s00.htm>

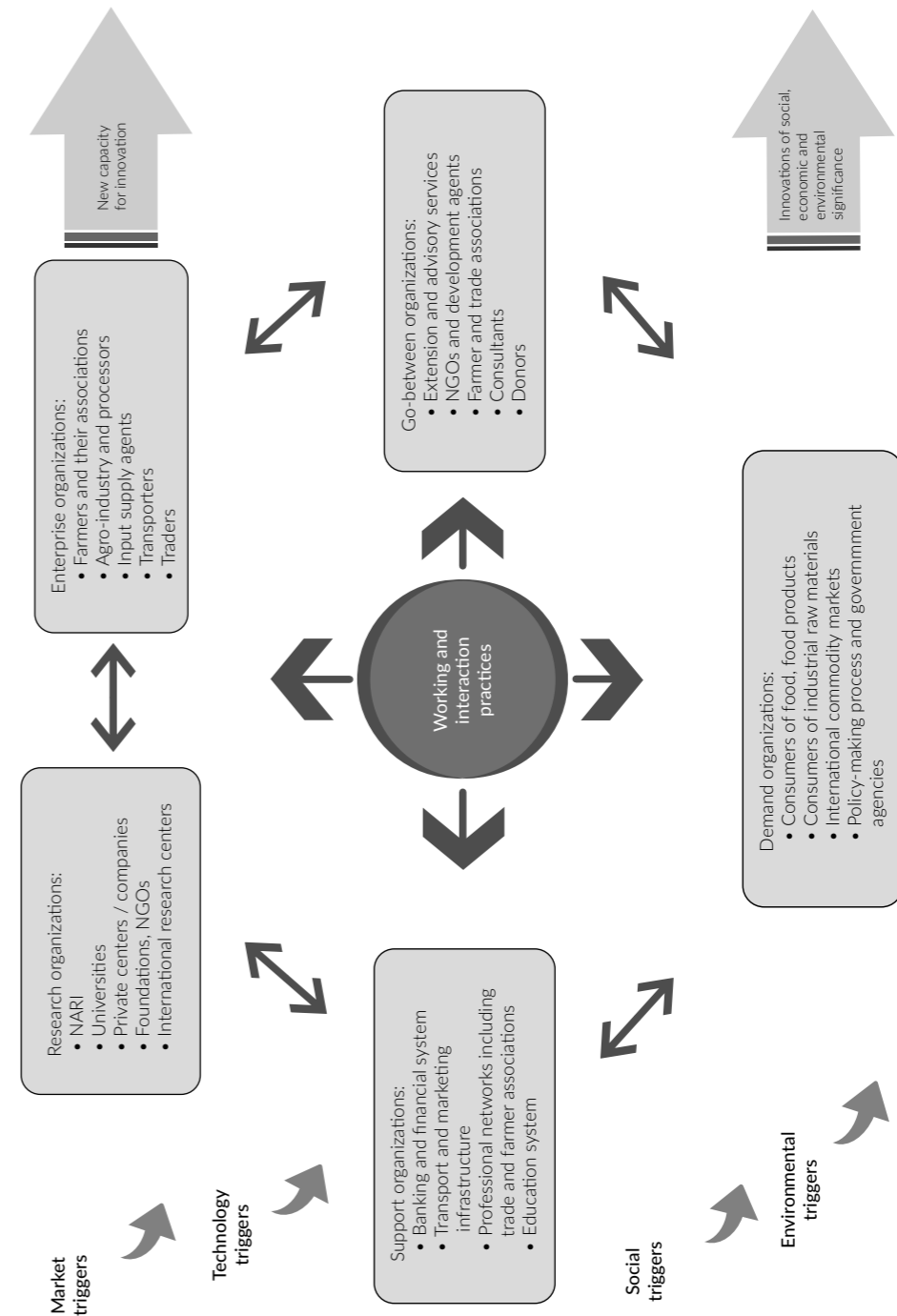


FIGURE 3. Policy and regulatory environment.

Source: Innovation in agriculture: a key process for sustainable development. San José, May 2014.

The availability of food depends on local production or the country's ability to import if food is not sufficient.

Accessibility is related with distribution and with the purchasing power of the population; in the case of relegated groups, accessibility mostly depends on social programs implemented by the governments.

Food quality and safety, the importance of a proper nutrition and water quality have been topics of ample discussion in recent decades. The idea of stable food systems mostly focuses on ensuring access to safe, healthy, high-quality food at all times, regardless of market changes or natural phenomena. The economic crisis that began in 2008 (which still persists) and the impacts of climate change have only underscored the importance of this issue.

One of the Millennium Development Goals is to halve, between 1990 and 2015, the proportion of people who suffer from hunger. Although statistics show that "the prevalence of hunger went from 20 % of undernourished people in 1990-1992 to 16 % in 2010", in view of the growing world population, there haven't been any advances in absolute terms. On the contrary, "the number of people suffering from hunger in developing countries has risen from 827 million in 1990-1992 to 906 million in 2010" (Sonnino and Ruane 2013:26-27).

Some African countries such as Congo, Ghana, Mali, Nigeria, and others such as Guyana, Jamaica and Nicaragua reached this goal toward the middle of the last decade; however, due to the population growth and the migration movements from rural to urban areas, food demand will only increase in the years to come. Estimations show that by 2050, food demand will be 70 % higher than it is today, reaching an increase of 100 % in developing countries (FAO 2009, cited in Sonnino and Ruane 2013:26-27).

The relentless advance of climate change cannot be stopped and the meteorological events that have taken place in the past years have had serious consequences for agriculture. The temperature rise expected for the end of the 21st century will cause a significant decline of agricultural productivity and will mostly affect the

geographical regions of Africa and Asia, where some of the poorest societies of the planet live.

The negative consequences of this phenomenon affect the most vulnerable social groups and increase the social inequality gap, which is already a reason for significant concern. Agriculture, on the other hand, has not only endured the effects of climate change (which will only worsen over time) but has also been one of the main causes of this problem. Agricultural activities are said to cause 15 % of greenhouse gas emissions at a worldwide level. Furthermore, logging and deforestation of natural reserves are activities that deplete the main natural resource that could compensate for the global warming caused by the increase of carbon dioxide in the atmosphere (Sonnino and Ruane 2013:26-27).

This situation calls for strategies and policies that can help reduce the level of soil degradation, avoid the disappearance of forests and reduce greenhouse gas emissions from agriculture. Farming practices need to shift towards becoming part of the solution instead of part of the problem.

Given the strategic social and economic importance of agriculture, world policies on food security have considered in recent years four priority areas: "1) increasing investments in agriculture; 2) expanding food access; 3) improving the governance of world trade; and 4) increasing productivity and preserving natural resources" (FAO 2009, cited in Sonnino and Ruane 2013:29).

The economic crisis, paired with the lack of resources and attention to other activities, has dramatically reduced public investments in agriculture in emerging countries. Globally, public funding for the sector fell from 19 % in 1980 to 5 % in 2010.

As a result, all States must swiftly reverse this situation. Support programs for the productive sector must gain new momentum, especially social protection programs that target the most vulnerable sectors. Likewise, the situation calls for international agreements to avoid the negative consequences on low-income countries, greatly affected by international market oscillations and who depend on food imports.

Finally, the productivity of small farmers must increase, to help improve their quality of life and possibly lead to a drop in food prices. Needless to say, this productivity increase must be accompanied by good agricultural practices and a better use of technology in a sustainable manner.

Evolution of agricultural innovation systems

During the 60s, governments would define the agenda for agricultural research, while the design and application of technologies would fall within the scope of public research institutions. Agricultural extension services, on the other hand, would be responsible for disseminating knowledge and state-of-the-art technology. The structure was linear, unidirectional, top-down, and was successful especially during the Green Revolution. However, the flow was also slow, expensive and failed to include the farmers' feedback. The generated technologies did not always respond to the needs of smallholder farming.

Years later, this linear approach was replaced by a different one, in which farmers were the beginning and end of the agricultural innovation process. The process started with the needs of farmers and ended with the offering of technological solutions originated in research centers, to complete a circular process (farmers to farmers). The private sector, non-governmental organizations and universities participated actively, and this system that included all stakeholders and institutions was called "national agricultural research systems" (NARS).

In the year 2000, FAO and the World Bank proposed the concept of "agricultural knowledge and information systems for rural development", with the purpose of promoting mutual learning between stakeholders and institutions. Its goal was to integrate education, research and extension, and promote interaction between these elements focusing on the rural population.

The concept of agricultural innovation can be summarized as "a process of generation, access, exchange and application of knowledge, through which the different stakeholders learn and innovate together, prioritize risks and share the benefits [...] The linear model of research-knowledge-adaptation-use is thus replaced

by an interactive one, with a high level of knowledge exchange during the process of recognizing the issues and searching for solutions, which proposes an evolution of the role of farmers, who go from being partners to becoming the centerpiece of innovation processes" (Sonnino and Ruane 2013:36).

Agricultural Innovation Systems (AIS), on the other hand, are networks of institutions, businesses, organizations and individuals that request and provide knowledge and technologies, and use novel products, processes and forms of organization, implementing innovative rules and mechanisms through which they interact" (World Bank 2000, cited in Sonnino and Ruane 2013:36).

TABLE 4. Stakeholders of agricultural innovation systems.

SECTORS	AGRICULTURAL INNOVATION STAKEHOLDERS
Productive sector	1. Farmers' associations. 2. Cooperatives.
Private sector	1. Providers of inputs, services, technical assistance. 2. Agribusinesses. 3. Financial organizations. 4. Food processing industries. 5. Collection centers.
Public sector	1. Public universities. 2. Research institutions. 3. Agricultural extension services. 4. Local ministries and authorities. 5. Quality assurance agencies. 6. Food safety and health services.
Civil society	1. Non-governmental organizations.
International organizations	1. International research centers. 2. International development agencies.
Media	1. Rural radios. 2. Other media.

Source: Sonnino and Ruane 2013:37.

If the goal is to develop efficient, inclusive and integrated innovation systems that respond to the needs of farmers, beneficiaries must participate in the design of agricultural innovation policies and be able to show how important they are, so that they can receive the support and recognition of societies and governments alike. At the same time, in order to make changes in agricultural research, extension and education systems, it is necessary to develop a more efficient communication between all stakeholders of innovation promotion processes. This includes the reorientation of participating institutions and the development of capacities such as communication, social negotiation and conflict management (Sonnino and Ruane 2013:38).

GENERAL STRATEGIES AND GUIDELINES DEFINED BY INTERNATIONAL ORGANIZATIONS

Innovation has significantly contributed to increasing production and food availability, mitigating the impact of famines and raising the level of nutrition in relegated populations. It has also significantly increased the income of farmers. Innovation has become an indisputable tool to address the major challenges faced by humanity, including climate change.

Innovation is one of the key issues in the agenda of international organizations. In the United Nations Millennium Development Goals Summit, held in New York between September 20 and 22, 2010, the Heads of State and Government pledged to increase their efforts to achieve the first Millennium Development Goal, eradicating extreme poverty and hunger by implementing actions such as:

Increasing the growth rate of agricultural productivity in developing countries through promoting the development and dissemination of appropriate, affordable and sustainable agricultural technology, as well as the transfer of such technologies on mutually agreed terms, and supporting agricultural research and innovation, extension services and agricultural education in developing countries (UN 2010).

FAO, on the other hand, pointed out that although no major famines are expected in the near future, 842 million people in the world suffer from chronic hunger and 70 % of them live in rural areas of impoverished countries. The marginalization and malnutrition problem is paired with the challenge of feeding a world population that continues rising and a society that demands more and better food.

In the words of the Director-General of this organization (FAO 2015a:vi):

The quest is now to find farming systems that are truly sustainable and inclusive and that support increased access for the poor so that we can meet the world's future food needs. Nothing comes closer to the sustainable food production paradigm than family farming.

As a result, the UN declared 2014 as the International Year of Family Farming (IYFF), through a resolution dated December 22nd 2011. In this resolution, the UN General Assembly encourages FAO, the governments, The United Nations Development Program, The International Agricultural Development Fund, the Consultative Group on International Agricultural Research and other relevant organizations within the United Nations System, as well as non-governmental organizations, to implement actions to support the International Year of Family Farming³.

In keeping with the premises of the IYFF, FAO defined four key objectives:

1. Supporting policies that promote sustainable family farming.
2. Increasing knowledge, communication and public awareness.
3. Better understanding the needs of family farming, its potential and limitations, and ensuring technical assistance.
4. Creating synergies for sustainability.

And three global action lines:

1. Promoting dialogue in decision-making processes concerning policies.

³ In this resolution, the UN states: "Recognizing the significant contribution of family farming and smallholder farms in attaining food security and poverty eradication, to achieve the development goals agreed upon internationally, included in the Millennium Development Goals". United Nations, A/RES/66/222.

2. Identifying, documenting and exchanging lessons learned and success cases on existing policies concerning family farming, at the national level and/or others, to tap into the relevant knowledge on family farming.
3. Communication, promotion and dissemination (FAO 2014).

That same year, FAO conducted a special study entitled "The State of Food and Agriculture: Innovation in Family Farming" (FAO 2015a). The report contains the first comprehensive estimate of the number of family farms in the world – at least 500 million. Additional analysis shows that family farms occupy a large share of the world's agricultural land and produce about 80 percent of the world's food (FAO 2015a:vi).

However, despite their social and economic relevance, family farmers have also been considered by many as "an obstacle to development and have been deprived of government support" (FAO 2015a:vi). That is the mindset, in the words of the Director-General of FAO, that we need to change. Governments, international organizations, civil society organizations, the private sector and research institutions must urgently recognize that family farmers are vital to the solution of the hunger problem.

Although family farms vary from country to country, their needs are similar: better access to technology, inputs adapted to their needs and which respect their culture and traditions; the inclusion of women and youth in agriculture; better access to land, water, credit and markets; higher participation in value chains; more equal access to education, health, drinking water and sanitation services.

In this document, FAO states that there are many ways to increase the potential of family farming, and one of them is to encourage connections between family farming and certain markets, promoting the use of traditional crops and prioritizing innovation:

These options all have a common feature: innovation. Family farmers need to innovate in the systems they use; governments need to innovate in the specific policies they implement to support family farming; producers' organizations need to innovate to respond better to the needs of family farmers; and research and extension institutions need to innovate by shifting from a research-driven process predominantly based on technology transfer to an approach that enables and rewards innovation by family

farmers themselves. Additionally, in all its forms, innovation needs to be inclusive, involving family farmers in the generation, sharing and use of knowledge so that they have ownership of the process, taking on board both the benefits and the risks, and making sure that it truly responds to local contexts.

We need a way forward that is as innovative as the Green Revolution was but that responds to today's needs and looks to the future: we cannot use the same tool to respond to a different challenger (FAO 2015a:vii).

During the IYFF, FAO recognized that family farmers are natural leaders, and can respond to the three main challenges that agriculture faces worldwide: improving food security and nutrition, preserving natural resources, and limiting the effects of climate change. The institution also stated that these farms must receive full support for innovation, and that governments, the private sector and the civil society have a shared responsibility in doing so.

Having said this, innovation itself is not sufficient to enable farmers who are lagging behind to overcome poverty. Governments need to implement integrated rural development policies and effective social protection. Innovation systems must adapt to the three types of farmers; the most advanced ones, who produce for the market and need no considerable support from the government, as well as middle -and small-sized farmers (FAO 2015a: xii-xiii).

Initiatives aimed at promoting innovation must follow the paradigm of sustainability. This involves the conservation and protection of natural resources and ecosystems, and boosting resilience in the face of climate change and market volatility. Providing environmental services, such as river basin protection, biodiversity conservation and carbon sequestering, among others, has become crucial.

In this same document, FAO points out that investing in agricultural research and development (R&D) is important for boosting agricultural productivity, preserving the environment and eradicating poverty and hunger. Indeed, the organization affirms that “much agricultural research can be considered a public good, where the benefits of the knowledge generated cannot be appropriated by a private company and is therefore

unlikely to attract the private sector” (FAO 2015a:xv). Here lies the importance of stronger public commitment in regards to agricultural research.

Furthermore, it is essential to promote cooperation between the countries in order to combine efforts and create synergies that can benefit countries with insufficient resources in the first place, in order for them to develop their own research.

Equally important is the provision of agricultural extension and advisory services. Too many farmers, especially women, do not have regular access to such services, which must be considered public services. Therefore, it is crucial for governments to participate and commit to these objectives. The adopted models must be inclusive, adapted to the needs of farmers and must prioritize participatory learning models (FAO 2015a:xiii-xvi).

Innovation is a complex process, developed at the individual, collective, national and international levels. It includes farmers, extensionists and researchers. Special attention must be paid to young farmers and women, both young and adult, and turn farming into an attractive option for their life. It is also necessary to promote farmers' organizations, and their association and cooperation with national and international research institutions. The role of public management is key in creating a favorable environment for the development of innovation.

The main messages contained in the FAO document are (FAO 2015a: xvii-xviii):

- ➔ *“Family farms are part of the solution for achieving food security and sustainable rural development; the world's food security and environmental sustainability depend on the more than 500 million family farms that form the backbone of agriculture in most countries. Family farms represent more than nine out of ten farms in the world and can serve as a catalyst for sustained rural development. They are the stewards of the world's agricultural resources and the source of more than 80 percent of the world's food supply, but many of them are poor and food insecure themselves. Innovation in family farming is urgently needed to lift farmers out of poverty and help the world achieve food security and sustainable agriculture.*
- ➔ *Family farms are an extremely diverse group, and innovation systems must take this diversity into account. Innovation strategies for all family farms must consider their*

agro-ecological and socio-economic conditions and government policy objectives for the sector. Public efforts to promote agricultural innovation for small and medium-sized family farms should ensure that agricultural research, advisory services, market institutions and infrastructure are inclusive. Applied agricultural research for crops, livestock species and management practices of importance to these farms are public goods and should be a priority. A supportive environment for producers' and other community-based organizations can help promote innovation, through which small and medium-sized family farms could transform world agriculture.

- ➔ The challenges facing agriculture and the institutional environment for agricultural innovation are far more complex than ever before; the world must create an innovation system that embraces this complexity. Agricultural innovation strategies must now focus not just on increasing yields but also on a more complex set of objectives, including preserving natural resources and raising rural incomes. They must also take into account today's complex policy and institutional environment for agriculture and the more pluralistic set of actors engaged in decision-making. An innovation system that facilitates and coordinates the activities of all stakeholders is essential.
- ➔ Public investment in agricultural R&D and extension and advisory services should be increased and refocused to emphasize sustainable intensification and closing yield and labor productivity gaps. Agricultural research and advisory services generate public goods – productivity, improved sustainability, lower food prices, poverty reduction, etc. – calling for strong government involvement. R&D should focus on sustainable intensification, continuing to expand the production frontier but in sustainable ways, working at the system level and incorporating traditional knowledge. Extension and advisory services should focus on closing yield gaps and raising the labor productivity of small and medium-sized farmers. Partnering with producers' organizations can help ensure that R&D and extension services are inclusive and responsive to farmers' needs.
- ➔ All family farmers need an enabling environment for innovation, including good governance, stable macroeconomic conditions, transparent legal and regulatory regimes, secure property rights, risk management tools and market infrastructure. Improved access to local or wider markets for inputs and outputs, including through government procurement from family farmers, can provide strong incentives for innovation, but farmers in remote areas and marginalized groups often face severe

barriers. In addition, sustainable agricultural practices often have high start-up costs and long payoff periods and farmers may need appropriate incentives to provide important environmental services. Effective local institutions, including farmers' organizations, combined with social protection programs, can help overcome these barriers.

- ➔ Capacity to innovate in family farming must be promoted at multiple levels. Individual innovation capacity must be developed through investment in education and training. Incentives are needed for the creation of networks and linkages that enable different actors in the innovation system – farmers, researchers, advisory service providers, value chain participants, etc. – to share information and work towards common objectives.
- ➔ Effective and inclusive producers' organizations can support innovation by their members. Producers' organizations can assist their members in accessing markets and linking with other actors in the innovation system. They can also help family farms have a voice in policymaking.

In the report's conclusions, FAO states that the future of nutrition in the world will be highly dependent on family farms, because “these farmers are called on to produce much of the additional 60 percent of food that the world's population will need by 2050” (FAO 2015a:104). And that, “at the same time, family farms will have to play a leading role in the continuing fight against hunger and poverty and in preserving the natural environment against spreading degradation and advancing climate change”.

The key for family farms to develop their full potential is innovation (FAO 2015a:104):

For many small farms, innovation means moving away from growing food principally for their own consumption and going into commercial production. It means adopting new approaches, technologies and practices that not only increase production and efficiency, but also do so in full respect of natural processes and ecosystems.

In order to achieve these goals, it will be necessary to refocus public policies, which in many cases benefit large-scale farmers and fail to support, finance or provide infrastructure, training and care to family farmers.

Family farms already produce the majority of the food consumed in the world, but they must receive support at the national and local levels. Throughout the process, the needs of each country and region will vary.

Large commercial businesses, on the other hand, will prosper in a favorable environment, with a solid support infrastructure and adequate regulations. Public research also favors them, and many farms are already integrated into innovation systems.

For small- and medium-sized businesses, the situation is quite different. Although some of them already work with the markets, others need further support to take that step forward; despite having the potential to do so, they require more credit facilities, suitable regulations, and specific research and advisory services.

Some farms still lag behind, fail to work with the markets and can barely produce their own livelihood. These businesses will find it very difficult to overcome poverty solely through farming; they rely on rural development public policies and social programs in which innovation, research and technology transfer are only a small part of a much more general policy.

Governments must establish differentiated strategies for these three types of farmers, and the same applies for women and youth. Women must face specific limitations to develop their innovation capacities; therefore, specific gender-based policies and strategies must be implemented. Young farmers, on the other hand, have a greater capacity for innovation than adults, and special attention must be paid to them in order to counteract migration from the countryside to urban centers (FAO 2015a:104-106).

Below are some of the areas that FAO considers crucial to promote smallholder farming and boost sustainable productivity (FAO 2015a:106-108):

Overcoming barriers and creating incentives to adopt technologies and practices for the sustainable growth of productivity. Key impediments for innovation include the absence of physical and marketing infrastructure, financial and risk management instruments, and secure property and land tenure rights, as well as difficulties to access credit. Local

institutions, such as producers' organizations, cooperatives and other community-based organizations, have a key role to play in helping farmers access marketing, financing and technical services.

Investing in research and development. Investing in agricultural research and development (R&D) is important for boosting and maintaining agricultural productivity. Given that research is a public good with long-term investments that have uncertain benefits and amortization periods, a commitment must be made by the governments for basic, long-term research. Low-income countries must strengthen their cooperation with more developed countries and with international organizations, and promote the cooperation between research institutes of countries that share the same challenges. Equally important is to ensure that this research addresses the needs of smallholder farmers, so that they can participate in their design to combine scientific research and traditional wisdoms.

Developing agricultural extension and advisory services. Agricultural extension and advisory services are crucial for farmers to access knowledge and technologies that will increase their productivity; however, many smallholder farms do not receive this type of support on a regular basis. Governments must ensure that these services are provided, and that they generate public goods. Governments must also provide services to develop more sustainable agricultural practices, preserving natural resources and mitigating the effects of climate change.

Promoting the capacity to innovate. Innovation capacity must be promoted at the individual and collective levels by educating and training all stakeholders. This involves the creation of a favorable environment that considers aspects such as governance, infrastructure, legislation and regulatory frameworks. It is equally important to boost and strengthen farmers' organizations.

Finally, the report on "The State of Food and Agriculture 2014: Innovation in Family Farming" defines the following key messages:

- *Family farms are part of the solution for achieving food security and sustainable rural development; the world's food security and environmental sustainability*

depend on the more than 500 million family farms that form the backbone of agriculture in most countries.

- *Family farms are an extremely diverse group, and innovation systems must take this diversity into account.*
- *The challenges facing agriculture and the institutional environment for agricultural innovation are far more complex than ever before; the world must create an innovation system that embraces this complexity.*
- *Public investment in agricultural R&D and extension and advisory services should be increased and refocused to emphasize sustainable intensification and closing yield and labor productivity gaps.*
- *All family farmers need an enabling environment for innovation, including good governance, stable macroeconomic conditions, transparent legal and regulatory regimes, secure property rights, risk management tools and market infrastructure.*
- *Capacity to innovate in family farming must be promoted at multiple levels.*
- *Effective and inclusive producers' organizations can support innovation by their members (FAO 2015a:108-110).*

At the United Nations Summit, held on September 25th 2015, the Sustainable Development Goals were approved and the Heads of State and Government made a commitment to intensify efforts "to end hunger and to achieve food security improve nutrition and promote sustainable agriculture" (Objective 2) by implementing actions such as [...]"':

2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment (UN 2015).

The OECD, on the other hand, has sought to promote the role of innovation in agriculture. More specifically, it has analyzed the role of the government and pointed out that innovation is crucial in improving the social, economic and environmental performance of the agrifood sector. The organization states that the countries must develop a sectoral innovation strategy in agriculture that considers the challenges

and opportunities existing in the spheres of sustainability, climate change and food security (OECD 2013). However, this sectoral strategy must be part of a much wider innovation strategy at a national level, and must translate into policies and regulations that affect the capacity of different sectors to create and adapt innovation. The inclusion of new evaluation criteria (indicators, for instance) is essential to assess the effectiveness of the policies implemented.

Another indispensable component is public investment in R+D. Undoubtedly, when agricultural innovation systems are strengthened, so are the activities of the private sector and the knowledge market when the results of public research activities are shared.

Education and agricultural extension, on the other hand, have a key role to play in helping farmers adopt innovations with a higher level of knowledge.

The coherence of policies is therefore crucial to improve the performance of agricultural innovation systems and agricultural and agrifood sectors. Clear objectives must be established to ensure that both the agricultural policy and the agricultural innovation policies are designed based on these goals to ensure consistency. The government must identify all possible obstacles to innovation and eliminate them. A favorable environment requires stable macroeconomic conditions, open and effective labor markets and regulations that will ensure transparency and contribute to enriching the human capital.

The goal is then to eliminate all obstacles brought about by distortions in the inputs market and all measures that may hinder structural adjustments. Investments must be encouraged, and property rights must be cared for, making risk management tools available for farmers according to their specific needs. Incentives and regulations must be technically neutral. Rural and trade infrastructure and services must be bettered and, above all, the competitiveness of the agricultural sector must be boosted to attract young and innovative people.

The government must continue offering the necessary knowledge infrastructure and funding basic and long-term research in order to strengthen agricultural innovation

systems. Furthermore, the governance of innovation systems could significantly improve provided it is able to integrate a global innovation strategy and improve the coordination between the different stakeholders and policies involved in said strategy. Given the complexity of innovation and its associated costs, strategic planning and monitoring and evaluation mechanisms are crucial, as are the cooperation mechanisms at the regional, national and international levels.

The association between the public and the private sectors must be encouraged, and measures must be implemented to make education and agricultural extension more efficient. The OECD has repeatedly claimed that there is no single model to ensure the efficiency of national agricultural innovation systems, but that it is important to foster cooperation between governments and agencies responsible for promoting innovation, and support a systematic exchange of information and experiences between different sectors and countries (OECD 2013:74-75).

The OECD has suggested the following reference framework to analyze the government's role in agrifood innovation (OECD 2013:76):

Economy-wide policies and innovation

- *Macroeconomic policies*
- *Governance systems*
- *Regulatory systems*
- *Financial markets*
- *Tax policy*
- *Competition policy*
- *Trade and investment policies*
- *Infrastructure and rural development policies*
- *Labor and land market policies*
- *Consumer and environmental policies*
- *Industrial policy and business regulations*
- *Health, education and information policies*

Agricultural policies and innovation

- *Policy objectives*

- *Domestic agriculture policy*
- *Agricultural trade policy*
- *Agricultural regulations*

Innovation policy and agricultural innovation systems

- *Innovation objectives*
- *Governance of innovation systems*
- *Investing in innovation*
- *Fostering knowledge flows: the role of networks and markets (IPR)*
- *Facilitating knowledge flows and linkages within national AIS*
- *Strengthening international cooperation on agricultural innovation*

Between 2013 and 2015, FAO and the National Institute for Agricultural Research (INRA) undertook a survey of innovative approaches that enable markets to act as incentives in the transition towards sustainable agriculture in developing countries. Through a competitive selection process, 15 cases from around the world (including Africa, Asia, the Near East and Latin America) provide insights into how small-scale initiatives that use sustainable production practices are supported by market demand, and create innovations in the institutions that govern sustainable practices and market exchanges (FAO and INRA 2016).

In this survey, both organizations study the institutional innovations that have allowed the creation of local markets for sustainably-farmed products. These innovation entail new rules and new forms of interaction that help redefine local sustainable practices and create linkages between stakeholders that did not work together in the past. FAO and INRA firmly believe that institutional innovations are as important as technological or agricultural innovations, that they are key in supporting a transition towards a more sustainable agriculture and that both innovations are strongly tied together.

The document also discusses the institutional arrangements in place that support innovations, which sustainable practices were applied and the trade channels used to sell the products. It also includes a description of institutional innovation, which describes aspects concerning governance and results (FAO and INRA 2016:xv).

Below is a summary of the conclusions of the study:

1. *Multilevel policy support is an important approach for public and private actors alike.*

- » *There are clearly different roles for different levels of government within each country. These roles need to be recognized and public support for municipal authorities is needed for them to be able to engage with local actors in these systems.*
- » *Local and national governments can promote these types of approaches within domestic markets, i.e. sponsoring activities, publicizing quality food or supporting local market outlets. Policy-makers can also look to neighboring countries to build regional alliances on these issues and solutions, which provide support to the debate on sustainable agriculture and international trade.*

2. *Regulatory instruments should incorporate room for flexibility in their implementation.*

- » *For these innovations to work, the basic legal and regulatory frameworks for supporting sustainable agriculture need to be in place. These frameworks should enhance the possibilities for small and medium-sized farmers to engage in – and particularly to contribute to – research and innovation activities and should be flexible enough to support diverse approaches in each local context.*
- » *Legitimacy is the most important role for public actors in these systems. Public actors can provide political opportunities for the institutionalization of innovations by recognizing ongoing grassroots initiatives in their countries as they develop their public policies and programs.*

3. *Incentives come through market relationships, but are not only favorable market prices.*

- » *Access to markets was an important component in these systems, but the incentive that these innovations provide is not only a favorable market price.*
- » *These initiatives were able to build a reputation for quality (e.g. safe, healthy food) in their local markets because of many different direct engagements and communication work.*

- » *There is a strong social component in how these innovations incentivize sustainable practices. Actors attached a great deal of importance to “belonging” to the collective and developing relationships around areas of interest for the members of each innovation.*
- » *The use of peer review and participatory research are clearly ways that can help producers and consumers to value their own knowledge and encourage their participation in these initiatives (FAO and INRA 2016:360-361).*

THE SITUATION IN THE AMERICAS

Family farming in the region

In Latin America and the Caribbean (LAC) there are approximately 17 million family farms made up of nearly 60 million people. 57 % of these units are in South America. This type of farm represents the majority of productive units in the region (75 %), although in countries like Brazil this percentage surpasses 90 %. The Latin American countries with the highest number of family farms are Brazil, with more than 4.3 million units, Mexico, with slightly less than 4 million, and Peru, with nearly 1.75 million.

In South America, family farming accounts for about 30 % of the production value and concentrates around 60 % of employment in agriculture. In Central America, it is responsible for about 50 % of the value of production and employs, except for Costa Rica, more than half the workforce of the sector. It is worthwhile noting that the surface area of these farms is not proportional to their importance; they cover a range that starts at 6.3 % of the total arable land (in Paraguay) and rises up to 57 % (in Colombia). Furthermore, certain products are mostly supplied by family farms: cassava and maize in Brazil, goat and pork meat in Argentina, tomatoes, beans and cassava in Paraguay (ECLAC *et al.* 2013).

The agrarian evolution in family farms of LAC has followed two main trends in recent decades. In countries like Argentina, Brazil and Chile, there has been a process of property concentration and disappearance of smallholder farms. On the contrary, in countries such as Mexico, Peru, Jamaica, Saint Kitts and Nevis and Antigua and Barbuda, the number of family farms has increased. This fragmentation of property, with the resulting intensification of the use of soil and the degradation it entails, emerges as one of the major challenges to overcome poverty in the region.

Another salient feature of family farms is their heterogeneity in terms of productive resources, infrastructure, capital and access to public goods and services. This in turn translates into an extraordinary productive potential, consumption and production structures, sources of income and innovation and market participation capacity.

FAO divides family farming into three types: “subsistence farming”, “transition farming” and “consolidated farming”. 68 % of these farms are subsistence units, 28 % are in a transition and only 12 % qualify as consolidated units. As a result, different productive development strategies and specific public policies must be applied for each type.

These farms usually face major challenges such as low-quality soils, difficulties in accessing technology, credits and services, poor or inexistent infrastructures, and difficulty accessing markets. Public investments are scarce and technical assistance programs dedicated to this task are not always the most adequate or fail to meet the farmers' needs.

Nevertheless, family farming has great potential for development; this is due to the fact that resources and labor are managed more intensively and that the farming practices employed are more equal and sustainable. These farms could certainly contribute to increasing food production, reducing malnutrition and poverty, and generating new jobs (ECLAC *et al.* 2013).

Family farming in Central America and Mexico

There are more than 2.4 million family farms in Central America, measuring in average 3.3 hectares. The size of these plots ranges from 1 hectare in Guatemala to 6.7 hectares

in Nicaragua. Productive diversification is applied in these productive units, mostly run by their owners, although in recent years waged work has gained importance. Non-agricultural income has also increased.

According to 2007 information provided by the ECLAC, the highest poverty levels (63 %) are concentrated in households dedicated exclusively to farming. The average of literacy in these families is 68 %; the average age, 48 years; the percentage of women who are heads of household is 9.3 %. 66 % has land tenure; 87 % are rural families with an average of 5.2 members per home; 90 % owns their home, and 52 % has access to electricity (ECLAC *et al.* 2013).

Central American family farming is mostly located in low-quality lands, highlands or dry areas near the Pacific. These areas have endured long droughts and will probably have to face the consequences of climate change in future years. The yield per land unit is low, about one half or one third of what is obtained in commercial agriculture with products such as maize or coffee. Family farmers also face serious limitations to access markets, since these units are not part of the value chain. Furthermore, they must sell their products to intermediaries, have no means of transportation, their products have quality and health problems, they produce at a small scale and they have no access to credit or work capital.

The aging of the population becomes evident (with negative growth rates already observed). Young workers tend to migrate to the cities and the average age of those who remain in the country has increased. Although almost all Central American countries have sectoral family farming programs, they generally lack a territorial approach and display a tendency towards domestic supply, productive chains, innovation, access to markets, poverty eradication and institutional strengthening. The public institutions in charge of these programs are the Ministries of Agriculture (ECLAC *et al.* 2013).

The region has implemented multi-lateral execution programs, such as the Regional Coffee Quality Program (PROMECAFE). This support initiative seeks to contribute to strengthening and increasing competitiveness in the coffee sector in Central America and the Caribbean. The program, created in 1978 after a cooperation agreement between IICA and the governments of Panama, Honduras, El Salvador and Costa Rica,

later joined by Mexico, Dominican Republic and Nicaragua, favors technology exchange between national institutes specialized in coffee, and joint research projects to strengthen the coffee sector (PROMECAFÉ n.d.).

Another initiative is entitled The Central American Program for Integrated Coffee Leaf Rust Management (PROCAGICA), officially launched by IICA and the EU during the inauguration of the II Regional Summit on Coffee Rust that took place in Guatemala City. This regional project aims at improving the socioeconomic problems faced by the coffee sector in Central America and the Dominican Republic after the outbreak of coffee rust that has affected the production of this grain since 2012. The program also seeks to help recover regional coffee cultivation and promote more sustainable production models from the economic, social and environmental perspectives. The program "has available 16.5 million Euros, of which 15 million were donated by the EU and are non-reimbursable, and will be implemented until 2021 through regional, national and local actions. The program will operate in El Salvador, Guatemala, Honduras and Nicaragua, and at the local level, in four specific areas of these countries" (SEAE 2016).

Finally, it must be pointed out that in 1994, the ministers of agriculture who are part of the Central American Agricultural Council agreed to create the "Collaborative network for vegetable research and development for Central America" (REDCAHOR) for which they requested the support of the Republic of China and the Central American Bank for Economic Integration (CABEI), and the participation of national and regional organizations. At the end of 1996, the three institutions together with IICA, CABEI and the Asian Vegetable Research and Development Center (AVRDC) signed an agreement with the purpose of creating a vegetable research and development network that included Guatemala, El Salvador, Honduras, Nicaragua and Costa Rica. Afterwards, by means of an agreement between IICA and the IDB, funding was obtained to strengthen the training component, which led to the inclusion of Panama and the Dominican Republic. From the very beginning, the main premise of the network was to address the national and regional agricultural development priorities in regards to vegetables, and to enable the necessary mechanisms to achieve a coordinated exchange of information, research technologies on vegetable development and training, whether originated in Central America or abroad. In order

to fulfill its goal of strengthening cooperation linkages between Central American countries and optimize vegetable research and development, the project involves public and private research facilities of each country as well as national or regional development institutions involved in these activities. The involvement of CATIE is highly relevant for the project's training activities (IICA n.d.c.).

Mexico, on the other hand, has 4.3 million family farms that account for 81 % of the total farming activity. Subsistence farming has an average of 3.4 hectares per unit and 2.6 people working in productive labor; transition agriculture has an average of 5 hectares per unit and 2.4 farmers; finally, consolidated family farming has an average surface area of 4.7 hectares and 1.7 family farmers at work. Overall, the technological level observed is low, with little integration into the productive chains, difficulty to access credits and markets, and degradation of natural resources. Only 5 % develops innovations. Programs dedicated to family farming in Mexico include the Sustainable Modernization of Traditional Agriculture program (MasAgro), promoting sustainable practices amongst maize and wheat farmers; the Strategic Good Security Project (PESA), which seeks to develop capacities in rural areas with high or very high levels of exclusion to increase agricultural production, apply innovation in production systems, develop local markets and create jobs; and the Support Program for Maize and Bean Productive Chains (PROMAF), the purpose of which is to strengthen competitiveness of smallholder maize and bean farmers by providing technical assistance, training, technological innovation, credit and organizational development, encouraging them to engage in more sustainable agriculture practices (ECLAC *et al.* 2013).

The productive potential of family farming in the region of Central America and Mexico could, undoubtedly, be further profited from by applying technological innovation. Yields could improve, which would in turn increase food availability and possibly reduce imports; more jobs would be created, especially for women and youth, and value chain participation would also rise.

Family farming in the Caribbean

Production and exports in the Caribbean region have dwindled in recent years, and the trade balance has deteriorated. The origin of this problem seems to be the

volatility of food prices in international markets. Except for Belize and Guyana, Caribbean countries import between 60 % and 80 % of the food they consume. This dependency is a serious threat to their food security. Furthermore, this sub-region has endured the effects of major natural phenomena such as hurricanes and earthquakes, like the one that devastated Haiti in 2010. The lack of information on the status of family farming does not allow a segmented differentiation as in the rest of the American countries.

Based on a 2012 study by Graham (cited in ECLAC *et al.* 2013:193), the most complete and updated source for analyzing agriculture in this sub-region, smallholder farmers in the Caribbean are between 41 and 54 years of age, work on surfaces smaller than two hectares and include campesinos who do not own the land they cultivate. Agricultural and fishing activities are performed traditionally and are mostly for self-consumption, although rural tourism and agroforestry are also common. Most families have land ownership, and only 10 % of the land is leased. 71 % of farmers are more than 40 years old, which means that the rural population is aging. Women's participation is low: only 30 % of them have land tenure. The family income resulting from farming activities has decreased. Crops have not changed in recent decades (they are basically vegetables, tropical fruit and sweet potato). Family farmers use traditional systems, including crop rotation and alternated crops. Monoculture and organic agriculture are rare. Yields are low, since most producers employ dry farming and are located in marginal lands or on hillsides. In general, they have no access to modern technologies although most countries feature national training programs on good agricultural practices. The problem lies in the lack of infrastructure, which makes progress more difficult. Most of the production goes to local markets, although a small sector has been able to access international markets.

Among the most outstanding farmers' organizations are the Caribbean Farmers' Association Network, which includes half a million farmers from twelve countries, the Caribbean Farmers' Association (WINFA) and other national farmers' associations. Some of the main challenges they face include improving access to technologies (to increase yields and productivity), information (to support the decision-making process), financing, agricultural lands and water resources, risk management mechanisms, and promoting farmers' organizations and partnerships (ECLAC *et al.* 2013).

Family farming in South America

Family farming in South America can be defined based on the level of access to land. In Paraguay, Uruguay, Argentina and Brazil, less than one fourth of the arable land is in the hands of family farmers, while in Ecuador, Colombia and Chile, more than half the land belongs to smallholder farmers. The average size of each unit varies significantly, ranging from 3 hectares in Colombia to 42 hectares in Argentina.

Some of the main agricultural products come from family farming. In Argentina, small-sized farms produce 82 % of goat meat and milk, and 64 % of pork meat; in Bolivia, almost all of the potato and yucca production; in Brazil, 87 % of yucca and 70 % of beans; in Chile, 94 % of goat products; in Ecuador, 85 % of onions and 83 % of sheep meat; in Paraguay, 97 % of tomatoes and 94 % of beans and yucca; in Uruguay, 80 % of vegetables.

As in the rest of Latin America, the feminization of agriculture can also be observed in South America: in average, 16 % of farms are headed by women, although the smaller the units and the lower the income, the higher this proportion is. Another remarkable fact is the concentration of indigenous people in family farming. In Ecuador, 25 % of the farms of less than 5 ha are indigenous-owned, and 23 % in Chile. The average age of family farmers is 55 years of age, which proves that as in the rest of the regions the population is ageing.

Although there is insufficient information on this sub-region, it has been proven that yields in family farming are about 30 % to 50 % below those of developed commercial agriculture. In Paraguay, 87 % of smallholder sugar cane farmers obtain less than 60 tons per hectare, while large-sized producers obtain more than 100 tons; for cassava, the proportion is 13 tons against more than 30. Another widespread problem is the difficulty to access export markets. In Chile, out of 255 thousand family farmers, only 5 % exports, 9 % sells to agroindustries and 3 % practices contract-based agriculture (ECLAC *et al.* 2013).

In 2004, in order to establish specific public policies for family farming, the Specialized Meeting on Family Farming was created within Mercosur. This meeting

seeks to promote trade in family farming through solidarity and complementarity, in an attempt to reduce asymmetries in the area, achieve food security, and overcome poverty and social exclusion by applying a new economic development pattern.

The governments of South American countries have implemented different programs aimed at strengthening family farming, including:

- **Argentina.** *Small Farmer Development Project of Argentina (PROINDER):* This project was created in 1998 to improve the living conditions of 40 thousand rural families of low-income sectors by financing productive projects. In 2007, a second stage began with 22 thousand families, with a program funded by the World Bank. Other projects include the Provincial Agricultural Services Program (PROSAP), a public investment tool aimed at financing projects to improve agricultural services in the provinces. The program works under the Secretariat of Agriculture, Livestock, Fisheries and Foodstuffs of Argentina (SAGPyA), and operates since 1992 to channel resources to the provinces and improve the infrastructure and services provided to farmers. It is executed with loans from the Inter-American Development Bank (IDB) and the International Bank for Reconstruction and Development (IBRD), and a national counterpart resulting from national and provincial budgets. The goal of PROSAP is to promote production, create jobs and foster agrifood exports. IICA services cover a wide range of activities including identifying potential projects or ex-post evaluations for social, education and infrastructure projects, as well as animal or plant health, agrifood competitiveness and quality, and business reengineering (IICA and PROSAP n.d.).
- **Perú.** *Rural Agrarian Productive Development Program (Agro Rural).* Created in 2008 after the merger of previous programs, it benefitted more than 158 thousand families in 2012 with activities such as water management, financing, insurance, forestation, business plan executions and trade.
- **Brasil.** *Family Farming Strengthening Program (PRONAF).* Created in 1995, the program supports the most vulnerable rural sectors by providing

subsidized credits, extension, training, infrastructure and marketing support (warranty prices and purchase of products for public programs). Its actions have included more than 600,000 farmers.

- **Chile.** *Agricultural Development Program (INDAP):* Promotes the productive and sustainable development of family farming by providing credits, agricultural insurance, technical assistance, irrigation, investment support, rural tourism and soil recovery. In 2013, it provided assistance to 135,000 farmers.

These programs and other activities developed by the ministries of agriculture seek to consolidate agricultural support institutions, create new support instruments, promote the insertion of farmers into the value chains, encourage the use of ICTs, enable access to the land and insert family farming into the global economy (ECLAC *et al.* 2013).

In order to favor the development of family farming in LAC, the study proposes the following “policy recommendations”:

- ➔ Generate information to characterize family farming and design relevant policies with an impact in the sector.
- ➔ Promote institutionalization for the development of family farming. [This entails]:
 - » Designing differentiated policies for separate segments of producers.
 - » A territorial approach as a key element in implementing policies.
 - » Policy creation that must be accompanied by a specific institutional design for family farming.
- ➔ Organizing productive development as a component of rural development through multisectoral strategies.
- ➔ Fostering and encouraging a future generation of farmers.
- ➔ Reorienting innovation systems for family farming.
- ➔ Adapting family farming to climate change, an essential action to ensure the sector’s continuity.
- ➔ Strengthen partnerships and collaboration, as the pillar for a better market insertion (ECLAC *et al.* 2013:212-215).

Innovation in Latin America and the Caribbean

The LAC region has been crucial in the changes experimented by agricultural innovation during the 20th century and in the present. The development of hybrid maize species during the 1930's, the high-yield wheat varieties discovered during the Green Revolution, as well as the use of genetically modified organisms to increase the yield of crops are a clear illustration of the commitment of the Americas with scientific and technological progress and innovation.

Agricultural research institutions have played a key role in this process. Throughout the 20th century, most Latin American and Caribbean countries created agricultural research institutes that later became consolidated public entities specialized in research during the second half of the century. These national institutes were generally conceived as decentralized organizations with administrative autonomy and a wide regional coverage (Trigo *et al.* 2013:viii).

The majority of advances achieved in research and development have been directly or indirectly related with these institutes, not only due to the knowledge and technologies generated, but also for their human resources and databases containing crucial information for the agricultural sector (soil, climate, plant variety, genetics, etc.). However, the changes observed in knowledge generation and technology application, where the private sector has an increasingly important participation, paired with the redefinition of the responsibility of the State in the economy over recent decades, have changed the role of governments in the promotion of innovation and development.

The IDB carried out a study to analyze how national agricultural research institutes in the countries of the region have included innovation and technological development. The document also proposes a series of actions that could lead to the adoption of new systems and approaches.

The agricultural sector in Latin America has undoubtedly undergone major changes in the past decades. Many sectors have been updated and were able to develop modern, competitive and high-quality production with international presence. Countries like Brazil, Argentina, Chile, Peru, Mexico or Colombia, to name a few, have consolidated agricultural

and agrifood sectors which now compete globally. However, many other sectors have lagged behind. The distance between them, in terms of productivity and efficiency, is far too wide. This is worsened by the fact that poverty in the rural milieu has only increased.

As mentioned in different international forums, agriculture is becoming one of the most relevant and dynamic sectors in national economies. Originally a mere producer of foodstuffs and fibers, it is now one of the main sources of clean energy. Research and innovation are key components that consolidate this transformation and represent an area of opportunity that must be valued and profited from. International organizations are aware of this and promote their full development. FAO, ECLAC and IICA have hosted meetings and conferences to analyze the situation of agriculture in the region, in order to promote food production and increase the efficiency and productivity of agricultural sectors.

After the Millennium Commitments were adopted, it has become certain that agriculture has a key role to play in reducing poverty, achieving food security and reaching environmental sustainability. In thirty years, agriculture will need to cover a worldwide food demand 70 % higher than the current one. It will also need to be able to significantly reduce poverty for more than one billion people who are barely surviving, revert the negative effects of climate change and provide environmentally-friendly energy. Agriculture in the 21st century is strongly linked to industrial transformation, but not just through the food industry but also by producing renewable raw materials. The paradigm of development is no longer based on achieving economic and industrial growth, and now includes the reduction of poverty and inequality, food security and environmental sustainability (Trigo *et al.* 2013:3-4).

The LAC region can play a key role in achieving these goals, not only because of the richness of its natural resources but also because it has made major progresses in including technologies to produce more food with green technologies, and because of its efforts to generate bioenergy and protect the environment.

Agricultural research in Latin America has focused strongly on poverty reduction, an issue that was mostly rural in the 80s when 74 of the 144 million people living in poverty were located in the countryside. More recently, Latin America has become a mostly

urbanized area and, in 1990, poverty was mostly located in cities. Nevertheless, in 2010 there were still 64 million people living in poverty in rural areas. Several studies have shown that the majority of poor smallholder farmers have insufficient land and must work with low-quality natural resources and insufficient infrastructure and services.

Within this context, it becomes clear that technological research and development alone are not sufficient to solve the problem of underdevelopment for these families. It is paramount to address other structural problems. As has often been pointed out, the obstacles that must be overcome to eradicate rural poverty are a consequence of ineffective efforts made in technological research and development, originally aimed at improving the productivity of neglected rural areas. This has been a major factor when considering the reduction of investments made on this type of project.

In recent years, resources allocated to agrifood research have mostly focused on improving the quality and affordability of food. However, research could also help family farmers become suppliers with higher value added products so that they can better integrate into markets and obtain a higher income (Trigo *et al.* 2013).

Globalization and trade openness have brought about more competition, but have also offered farmers in the region the possibility of accessing international markets as long as quality standards and consumer requirements are met. The more modern and efficient sectors have been able to insert themselves into these markets, but not traditional farmers. Competitiveness is clearly determined by the capacity to adopt new technologies regardless of their cost, and entering production chains by supplying inputs, processing and commercializing the different products.

In Latin America, "the degree of agroindustrial integration is below 30 %, as opposed to 80 % or 90 % reached in developed countries" (Trigo *et al.* 2013:5). Likewise, the growing involvement of transnational companies in agroindustrial development has a strong influence in the trade of food products in developing countries.

All of these factors determine the innovation response. Quality, sales opportunities, productive integration, demand and market segmentation must be given priority, promoting a joint approach to the agrifood chain (Trigo *et al.* 2013).

Advances in biotechnology and computer sciences are changing the way in which crops are produced and agricultural productive processes are organized; there is currently a closer relationship between research centers and farmers. The relationship between hard science and applied science, between lab work and field work has changed, as has the emphasis on training human resources, the relationship between researchers and research centers, and the relationship between these centers and public or private entities tied to the agricultural sector.

The private sector has certainly played a key role in the development of technological tools. Undoubtedly, the cost of these investments and the long testing and public authorization processes that must be followed to apply these technologies at an industrial scale are significant.

By 2010, private investments in R+D in countries belonging to the OECD were estimated at about 60 % of the total investment in this sector. In LAC, this number is much lower, but continues to grow (Trigo *et al.* 2013).

In the 80s, the region of LAC witnessed the creation of multiple foundations dedicated to supporting agricultural research. They constituted a link between the public sector and the farmers, and had the purpose of financing research and technology transfer projects. These foundations include:

Development Foundation of El Salvador (FUNDAGRO) in Ecuador, 1987, sponsored by the USAID and the Government of Ecuador; Salvadorian Development Foundation (FUSADES), in El Salvador, 1983, (sponsored by USAID); Honduras Agricultural research Foundation (FHIA), in Honduras, 1984, sponsored by the United Brands Co., the USAID and the Government of Honduras; the Services for Farmers Foundation (FUSAGRI), in Venezuela, 1972, sponsored by the Compañía Shell de Venezuela and 45 national companies; the Technological Support project for Export Industries (PROEXAG), in Guatemala, 1986, sponsored by ROCA/USAID; the Foundation for Agricultural Development (FUNDEAGRO), in Peru, 1988, sponsored by the USAID, the INIA and the National Agrarian organization (ONA); the Chile Foundation, in Chile, 1976, sponsored by the ITT (USA)

and the Government of Chile; the Costa Rican Coalition for Development Initiatives (CINDE), in Costa Rica, 1982, sponsored by the USAID; the Jamaican Agricultural Development Foundation (JADF), in Jamaica, 1986, sponsored by the USAID; the Foundation for Agricultural Development (now called Center for Agriculture and Forestry Development CEDAF), in the Dominican Republic, 1987, sponsored by CNHE (private), the USAID and the Government of the Dominican Republic (Trigo *et al.* 2013:14).

The private sector has implemented different strategic associations in order to promote research and technology transfer (Trigo *et al.* 2013:14). An example of this is the National Office of Produce Foundations A.C. (COFUPRO), in Mexico, which groups non-profit farmers' associations with legal status and patrimony, and seeks to promote research generation and technology transfer according to the needs of farmers. In the same line, other examples include the National Coffee Research Centers (CENI) in Colombia, created by coffee farmers' associations, and the Department of Research and Extension on Sugar Cane (DIECA) in Costa Rica, a scientific and technological entity operating exclusively with private resources and which concentrates, executes or coordinates most of the technology generation and transfer activities taking place in Costa Rica for sugar cane production, in coordination with the academic sector (LAICA 2012).

Other types of models have been implemented to promote innovation. These include sectoral funds, a modality applied in Brazil since the 90s that combines private, public and academic investments to boost research, development and innovation projects. Something similar occurs in Argentina, through the Argentine Technological Fund, which promotes research and development with public funds.

A different model can be found in Chile, where productive consortiums combine scientific and technological institutions with the private sector and work with resources provided by organizations such as the World Bank, the Production Development Corporation, the Ministry of Economy and the Foundation for Agrarian Innovation of the Ministry of Agriculture. Likewise, different research and crop validation studies are being conducted within the Regional Program for Research and Innovation by Agricultural Value Chains (PRIICA) for yucca, potato, tomato and

avocado, for example, as well as strategic innovation plans to be implemented in Central American countries.

The agrifood research system in Latin America and the Caribbean: National Agrarian Research Institutes or Agricultural Technology Institutes

Almost all the countries in the region have a public research institutions (NARIs) or agrifood technology institute (ATIs). The NARIs were created at the end of the 1950's, a time when societies were mostly agrarian, the population was predominantly rural and most farmers were detached from the markets, practicing self-consumption economy. Only a small part of agricultural activities were integrated into trade circuits through the export of commodities. Back then, the premise was that these research institutes would contribute to modernizing the agricultural sector through technology transfer, mainly generated in developed countries. The development of a more modern and competitive agriculture was tied to urbanization and industrial growth processes. In this context, agriculture would play a key role by supplying inputs and foodstuffs for growing urban societies.

Another idea at the time was that technology generated in developed countries was sufficient, and could adapt to the different types of agricultural sectors in developing countries. The NARIs began developing research activities that until then had been carried out by the ministries of agriculture. Some of them were also in charge of extension activities. Their goal was to address technological problems affecting primary production and promote the adoption of available technologies. The focus was placed on supply, failing to prioritize post-harvest or value adding through industrial processes. The first institute of this type was the National Agricultural Technology Institute of Argentina, created in 1956, whose model was adopted shortly after in the rest of the countries of the region (Trigo *et al.* 2013:18) as observed in the following list:

- National Agricultural Research Institute (INIAP) in Ecuador (1959).
- National Agricultural Research Fund (FONAIAP) in Venezuela (1959/61); in 2000, it changed its name to National Agricultural Research Institute (INIA).

- National Research Institute on Forestry, Agriculture and Fisheries (INIFAP) in México (1960).
- Agricultural Institute of Colombia (ICA) in Colombia (1963).
- National Agricultural Research Institute (INIA) in Chile (1964).
- Agricultural Science and Technology Institute (ICTA) in Guatemala (1972).
- Brazilian Agricultural Research Institute (Embrapa) in Brazil (1972).
- Bolivian Agricultural Research Institute (IBTA) in Bolivia (1975).
- Agricultural Research and Development Institute (IDIAP) in Panama (1975).
- National Agricultural Research Institute (INIA) in Uruguay (1989).
- Agricultural Research Office (DIA) in Paraguay (1992).
- National Agriculture and Forestry Technology Center (CENTA) in El Salvador (1993).
- Nicaraguan Agricultural Research Institute (INTA) in Nicaragua (1993).
- National Innovation and Technology Transfer Institute (INTA) in Costa Rica (2001)⁴.

At first, State intervention was key in promoting technological development due to the nature of the technologies employed, which were mostly public goods. For instance, the use of improved seeds, fertilizers and capital goods was predominant for food production. Public policies at the time included subsidies for productive activities and funding for emerging food processing industries. The State was the pillar of economic development, and its involvement was palpable in different strategic areas of the economy.

Simultaneously, the international agricultural research centers were created with the sponsorship of the Consultative Group for International Agricultural Research (CGIAR). These centers fostered the association between national research centers and the centers of excellence in developed countries, focusing on harvesting, improvement, evaluation and distribution of the germplasm, as well as the training of scientists in the

⁴ It is also worthwhile mentioning the Tropical Agricultural Research and Higher Education Center (CATIE), a regional center focused on research and higher education on agriculture, management, conservation and sustainable use of natural resources, whose members are Belize, Colombia, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Venezuela, IICA and the State of Acre in Brazil. CATIE was created in 1942 and its school began working in 1946.

different countries of the region paying special attention to the most relevant crops. The International Center for Maize and Wheat Improvement (CIMMYT) in Mexico, the International Tropical Agriculture Center (CIAT) in Colombia and the International Potato Center in Peru were created between 1996 and 1972. Since their creation, these institutes have consolidated their position as key institutions for the regional research and technology transfer system, with highly trained scientists who have access to financing for their research and who do not have to deal with the obstacles of bureaucracy and political pressure.

Around 1980, agricultural research institutes of the first generation were able to reach their original goals; increasing productivity and keeping food prices low, in order to strengthen industrialization in the countries of the region. Their purpose was to increase the supply of agricultural products for export, including foodstuffs and commodities, boosting the productivity of a group of key crops. The IDB stated that “work was done with commodities for undifferentiated clienteles and markets, where the supply side prevailed as a central criterion for selection of priorities” (Trigo *et al.* 2013:18-19).

The economic transformation that took place after the 1980s also changed the development of the agricultural sector, its insertion in the global economy and the needs that had to be addressed. The crisis of the import substitution model, the indebtedness of governments, the exhaustion of systems like the agricultural frontier or extensive agriculture, the economic crisis and currency devaluations triggered the need to adopt a new economic model and obtain economic relief from international financial organizations. These actions led to macroeconomic adjustments policies imposed by governments, which in turn redefined the role of the states as pillars of economic growth. The wide institutional network that accompanied the agricultural sector through multiple official institutions, subsidies and support was dismantled. The support policy that was in place for productive sectors gave way to policies that sought to find a more integrated way to overcome poverty and promote rural development. Funding for research and technology in productive sectors was only a small part of a series of programs aimed at creating an infrastructure for communication, health and education services for the most marginalized sectors, providing them with assistance and ensuring their market access capacity.

Agricultural extension has always been part of these national research institutes, following a model in which knowledge and technology were transferred to farmers, especially small-sized ones. This model also underwent radical modifications, and currently features the following characteristics:

- Service is co-financed by direct beneficiaries;
- Service is more client-oriented and includes more participation by beneficiaries;
- Delivery service is decentralized; and
- Delivery service is outsourced.

Extension services are no longer the sole responsibility of national research institutes, as was the case during the first stage; on the contrary, these services have diversified and can also be provided by non-governmental organizations. Furthermore, the services provided are no longer only technical, but now feature informal education, development management, well-being and institutional changes, to name a few.

Due to these changes, the NARIs were forced to modify their structure and the way in which they operate, adapting to their new role as promoters of rural development. As a result of this new approach, research and knowledge generation have become neglected.

Another major problem has been insufficient integration of agricultural research institutes into national university research systems. The NARIs have generally fallen under the ministries of agriculture which are not linked to the national research programs. Although there have been some signs of progress in terms of coordination between these instances, there is still a long way to go for agricultural research to become part of the research carried out by academic institutions. A successful example that can be mentioned is the Innovagro network, sponsored by IICA and COFUPRO in Mexico, which will be referred to separately.

In the LAC region, public institutions concentrate most of the available human and financial resources for research and development. Universities have the strongest position, although the research they produce still fails to translate into the productive systems (Trigo *et al.* 2013:26).

The basic problems are the insufficient investments made in agricultural research, and the high concentration of resources in only a few countries. In 2005, estimates showed that Brazil accounted for an average of 50 % of the resources allocated to agricultural R+D in the region, followed by Mexico with 20 % and Argentina with 8 %. Some of the most consolidated NARIs also concentrate the majority of the resources allocated to this activity: the national research institute of Uruguay receives 60 % of the total resources invested in the country; the INTA in Argentina, 59 %; and EMBRAPA in Brazil, 57 %. Although since 1990 resources allocated to this sector have increased, they are still insufficient and regional contrasts persist. Central America continues to be the area with the slowest progress in this sense (Trigo *et al.* 2013:28).

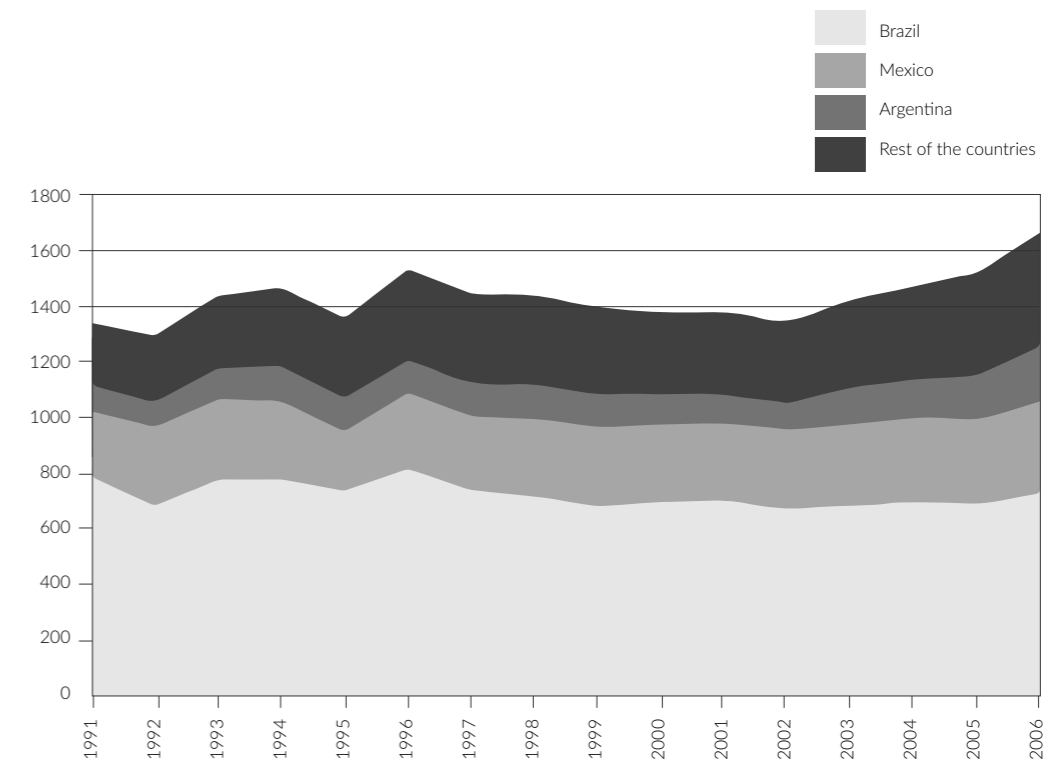


FIGURE 4. Trend in expenditure in millions of USD in Latin American countries, breaking down share of Brazil, Mexico and Argentina in overall outlay.

Source: Trigo *et al.* 2013:28, created based on data from ASTI 2011.

Human resources dedicated to agricultural research also tend to concentrate in government institutions (the NARIs have 60 % of these resources), followed by universities and higher education centers. As for the number of researchers, Brazil (with 4351), Argentina (with 3865) and Mexico (with 3824) are at the top of the list, followed at a distance by Colombia (962), Chile (697) and Uruguay (399) (Trigo *et al.* 2013:29, with information from ASTI 2008).

The authors also state that the budgetary allocations for plant breeding, one of the most relevant research areas in the agricultural sector, has been reduced by more than half since 1990 (Trigo *et al.* 2013:32).

A study conducted by Sain and Ardila in 2009 (cited in Trigo *et al.* 2013:36) categorizes countries in the region according to their capacity to generate and profit from technologies, and adapt them to their local context. For this analysis, the authors developed an index of “scientific capacity” (number of researchers and publications), an index of “innovation capital” (number of researchers per unit of surface area and investment in research as a % of agricultural GDP) and an index of “imitation” capital (level of education and number of extension workers per unit of surface area). They reached the conclusion that only Brazil, Argentina, Mexico, and Chile have a high capacity to generate and profit from what they call technological “spillovers”; Venezuela, Cuba, Colombia, Uruguay, Costa Rica, Peru, Panamá, Jamaica and Ecuador have a medium capacity, and Bolivia, Honduras, Guatemala, El Salvador, Nicaragua, Paraguay, Dominican Republic, Haiti, Belize and other Caribbean countries in that order, have low capacity.

This data shows the diversity that characterizes agricultural research systems in the region: five countries concentrate the majority of the capacities, while the rest lacks infrastructure, funds and human resources.

This situation is a reflection of the paradigm change observed in the role of the State in economy and development, and which has redefined the organizational and management model for research and development in LAC. On one hand, the State is no longer perceived as the sole responsible for promoting development; at the same time, there is a general perception that the participation of civil society

is fundamental, and that it is necessary to implement a more open and inclusive public management and organization system. Deregulation, privatization and transfer of responsibilities to local governments have become increasingly relevant, as well as a stronger involvement by the private sector in the financing and promotion of agricultural research.

An assessment of the most profound and systematic reforms suggests they were guided by the following principles:

1. *Science and Technical policy should promote institutional systems where public research is articulated with other institutions. Research networks and other mechanisms for inter-institutional cooperation that foster scientific exchange, cooperation and synergy, are central elements for dealing with the growing complexity of science. In particular the close association of research with university education improves the efficacy of research and contributes to updating and renewing scientific thought.*
2. *Within the Institutional System, normative functions -those concerned with defining science and technical policy and the allocation of research resources- should be separated from research and technology transfer activities. For this purpose, the establishment of councils integrated by public and private participants is an option of growing interest.*
3. *The financing of research is a powerful instrument for achieving the following things: i) the pertinence of research; ii) the coordination and cooperation of the different institutional components of the scientific and technical system; and iii) efficacy in the use the resources. In this light, part of the funds allocated to research should be used to finance programs and projects using competitive mechanisms.*
4. *Science and technology systems should have mechanisms for social control to ensure the relevance of their activities and the transparency and efficacy of their management. Mechanisms for social control include boards of directors to help define priorities and financing. They are a necessary counterpart*

to the administrative and bureaucratic controls characteristic of Public Sector administration.

5. Research institutions need organizational structures and management styles compatible with research. For this purpose, it is appropriate for research and technology transfer activities to be conducted in small operational units and with a high level of decentralization and functional autonomy, including the possibility of operating within the private sector. Such organizations should have few hierarchical levels and horizontal management that allows for flexibility to adapt to the changing needs of the environment. Organizations of this kind allow for the development of an institutional culture and human resources policy in tune with the needs of scientific activity and the scientists own idiosyncrasies (Trigo et al. 2013:37-38).

It is therefore essential to discuss the way in which agricultural innovation must be redefined in order to fulfill its role. Agricultural innovation must acknowledge that scientific research capacities are not limited to agrarian sciences, but include other disciplines such as chemistry, food science, engineering and market management to name a few. It is also necessary to recognize that these capacities are distributed in different institutions, both public and private and at the national and international levels. Articulating and guiding the agrifood sector towards the solution of specific needs becomes crucial. The study conducted by Trigo et al. (2013:41) features the following illustration of the national agricultural innovation system (figure 5).

That said, the cost of infrastructure, human resources and technology is a major obstacle for many of the small countries in the region. In the past, the problem was addressed through external resources (cooperation for development funds, loans by international banks, etc.); however, whenever these resources dwindled or disappeared, the institutions that provided support to the projects vanished. Another issue was the lack of qualified labor. In this context, research and development in public and private institutions in the future will focus on developing and maintaining strategic capacities, and will have less direct participation in specific technology development activities, except in areas with a clear social content such as family farming, or with a predominance of public goods, such as environmental protection (Trigo et al. 2013: 44).

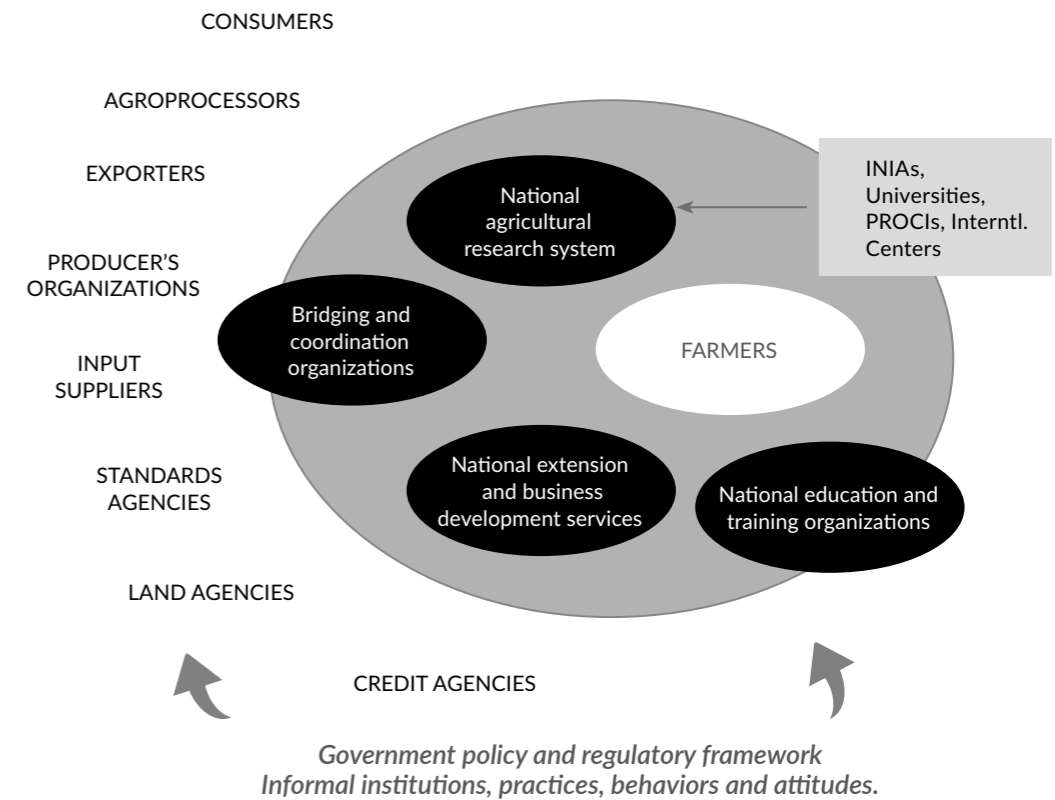


FIGURE 5. National System for Agricultural Innovation.

Source: Trigo et al. 2013:41, adaptation of presentation by W. Jansen at Innovagro.

It is very likely that the cost of developing specific technologies will need to be borne directly by the beneficiaries.

The public institutions in charge of these activities are also expected to become small operative structures, but with a great capacity for inter-institutional coordination. The state, on the other hand, will continue to take on the responsibility of defining and applying regulatory frameworks and providing access to funding for research and development activities (Trigo et al. 2013: 44-45).

The LAC region has many strengths, one of them being its network of research and technology transfer centers built over the course of several decades. Apart from the NARIs and the CGIAR, other important institutions include the CATIE, the Caribbean Agricultural Research and Development Institute (CARDI), the Forum of the Americas on Agricultural Research and Technology Development (FORAGRO) and the Regional Agricultural Technology Fund (FONTAGRO). Other programs include the Regional Cooperative Program for Technological Development and Modernization of Coffee Production in Central America, Dominican Republic and Jamaica (PROMECAFE), the Cooperative Program for Agrifood and Agroindustrial Technological Development in the Southern Cone (PROCISUR), the Cooperative Program on Agricultural Research and Innovation and Technology of North America (PROCINORTE) and the Cooperative Agricultural Research and Innovation Program for South American Tropics (PROCITRÓPICOS), all regional cooperation programs aimed at strengthening research, innovation and technology transfer in different regions of the continent for some of the most relevant agricultural products.

Although the key role played by these institutions, programs and forums is undisputable, it is necessary to revitalize them so that they can effectively contribute to developing the new innovation schemes required by current scenarios. This involves strengthening international cooperation and exchange of research experiences with productive sectors, modernizing these sectors and helping them create closer ties with the private sector. New financing mechanisms must also be developed, combining public and private efforts in a more streamlined and efficient way.

The IDB study proposes the following general strategy to strengthen agricultural innovation (Trigo *et al.* 2013:50):

National system of innovation

- A. Develop strategy for the national system of agricultural innovation, within which the relevant actors, capacities, policies and priority lines are identified.
- B. Implement adjustments in regulatory and support frameworks for innovation in areas such as intellectual property, biosafety and animal and vegetable hygiene, systems of standards and measurements, and quality systems, among others.

System of research and technology transfer

- a. Need to structure a discussion with regard to public sector roles and priorities.
- b. Develop new tools to increase private financing of research and technology transfer.
- c. Establish mechanisms of institutional government and decision making more oriented towards the market and demand to ensure greater participation not only of producers, but also of other actors involved, especially agroindustrial players.

Agricultural research institutions

Strengthen them with regard to:

- i. Institutional and organizational frameworks to create a greater and more effective participation by the different actors, and financing structures that are more responsive to the characteristics and requirements of research activities;
- ii. the development of their human resources and infrastructures - laboratories and data bases - both in conventional areas as well as in new sectors (biotechnology, precision agriculture, post-harvest and agroindustry);
- iii. management capacities in key questions of new processes of research and technological development (intellectual property, cosortium projects, technological linkage, biosafety, etc.), and
- iv. arrangements and instruments for articulation among the various actors of the technology transfer systems (knowledge management, policies and mechanisms for management of operational partnerships, etc.

The document also acknowledges the complexity of innovation, and the role of economic stakeholders (including those working in the agricultural sector), and proposes to focus on:

1. "Strategies for the national systems of agricultural innovation within which actors, capacities, relevant policies and priority lines are identified [...]."
2. "The implementation of adjustments in regulatory and support frameworks for innovation in areas such as intellectual property, biosafety, animal and plant health, systems of standards and measurements and quality systems, among others" (Trigo *et al.* 2013:51-52).

The document concludes by stating that research must be strengthened in order to promote agrifood innovation, given that “agriculture is repositioning itself with respect to its role in development policy, whether because of food prices, or due to the need to respond effectively to climate change, or because of the new realities of a world with more expensive energy [...]” (Trigo *et al.* 2013:54). The study also discusses the fact that innovation is crucial and requires further investments. Agrifood research institutions must no longer be isolated from the rest of science and technology institutes, and the gap that separates some countries from others in terms of human and institutional resources must be bridged.

In 2013, FAO, ECLAC and IICA published a study entitled *The Outlook for Agriculture and Rural Development in the Americas: A Perspective on Latin America and the Caribbean*, in which they underlined the importance of innovation, specifically production technologies, including biotechnologies, as tools to improve crop production in family farming and face the challenges of climate change. They also pointed out that for technology to efficiently and proactively address the development of varieties that are adapted to new climate conditions, it is necessary to strengthen national science, technology and innovation systems, and modernize and reorient extension services in order to turn extensionists into truly trained innovation agents (ECLAC *et al.* 2013).

They also observed that several countries in the region had strengthened their national agricultural and forestry innovation systems (for example, Bolivia), as well as different programs aimed at promoting innovation in agricultural and forestry activities for family farming (El Salvador, Barbados, Granada, Argentina, Colombia) (ECLAC *et al.* 2013).

Furthermore, a study conducted by IICA, entitled *Innovation in Agriculture: a key process for sustainable development* (French *et al.* 2014), points out that the evolution of food crops in Latin America between 1961 and 2011 show a stagnation and even a setback after the year 2000, in contrast with the increase showed by the United States and Canada and even the world average for that same period. This behavior is associated with factors such as changes in the productive structures, inclusion of marginal lands and lower investments, but can also be attributed to

insufficient and unsuitable production technologies. Likewise, when comparing the increase in agricultural production of the main crops of LAC with the rest of the world, the region displays lower yields of oilseeds, vegetables, roots and tubers, and fruits, and is only higher when it comes to cereal production. This illustrates the need to strengthen innovation as a tool to improve productive competitiveness in Latin America and the Caribbean.

This same document also points out that “Investment in agricultural research and development (R&D) has been shown to improve economic growth, agricultural development and poverty reduction in LAC over the past fifty years” (French *et al.* 2014:9). It also cites different studies to point out that investments made in agricultural research is highly profitable, showing an internal return on investment rate of 46 %, similar to the ones observed in other developing economies.

The document points out that between 1990 and 2011, the ratio between R&D expenditures in all sectors of the economy and gross domestic product (GDP) places LAC on a slightly rising trend starting in the mid-2000s. Most of this trend (70 % of investments) can be attributed to Brazil, and investments were barely 0.75 % of GDP even in the highest instances, which is considered insufficient to meet the region’s production needs. In the United States, this percentage is closer to 3 %.

One of the most relevant events among the activities organized in celebration of 2014 as the International year of Family Farming was the regional Latin American Forum entitled “Rural Development, Innovation and Rural Communication”, organized by FAO together with the Ministry of Agriculture of Brazil and the Brazilian Agricultural Research Company (EMBRAPA).

The Forum, which took place in Brasilia on November 12-13, 2015, in the framework of the “Regional Initiative II, Family Farming and Territorial Rural Development” of FAO, included the participation of institutions from 15 countries in the region. Its objectives were (FAO 2015b:1):

1. Share relevant approaches and experiences for territorial development and innovation for family farming in Latin America;

2. Appreciate the value of knowledge exchange and communication for development, as a key component for participation, decision-making and research and rural extension processes;
3. Identify priorities, institutional options and partnerships for the implementation of technical assistance and rural extension (TARE) services and efficient, socially inclusive rural communication; and
4. Develop proposals and recommendations to strengthen policies and national and regional programs for territorial development, family farming, innovation and communication for rural development, promoting cooperation between the countries of the region on these issues.

The conclusions pertaining the issue of territorial development, family farming and innovation were (FAO 2015b:2-3):

Policy and program strengthening:

- » Structure public policies, involving communities and organizations, respecting local and regional diversity with the participation of all actors.
- » Consider and institutionalize the systemic dimension and the participative management of territorial development for programs and projects involving TARE policies.
- » Ensure that all rural and territorial development actions and policies are socially inclusive.
- » Increase the South-South exchange of experiences and cooperation concerning territorial development policies, family farming and TARE between countries and regions.

Future steps:

- » Efficient communication processes must be built to create and disseminate policies and promote engagement.
- » Foster the exchange of experiences and partnerships between the countries to generate family farming policy proposals and build consensus on TAREs between the public sector and family farmers' organizations.

- » Knowledge must be built collectively, involving good family farming practices and respecting the processes of base organizations.

Finally, many countries in the LAC region have started developing stronger coordination and articulation between the institutions that make up their agricultural innovation systems. An example worthwhile mentioning is the case of the National Science, Technology and Technological Innovation Council of Peru (CONCYTEC).

Other relevant agricultural innovation systems in the region include:

- ➔ The National Agricultural and Forestry Innovation System (SNIAF) in Bolivia.
- ➔ Agricultural Innovation and Promotion of Competitiveness in Chile.
- ➔ National Agrarian Innovation System (SNIA) in Peru.
- ➔ The Agricultural Innovation System in Uruguay.
- ➔ The Agrarian Innovation System in Ecuador.

STRATEGIES AND GUIDELINES DEFINED BY IICA: MINISTERIAL DECLARATIONS AND STRATEGIC AND MEDIUM-TERM PLANS

IICA has fully acknowledged the importance of innovation in improving agricultural productivity in the Americas and successfully facing the challenge of boosting rural development, increasing the quantity of food, protecting natural resources and mitigating the impact of climate change.

In its 2010-2020 Strategic Plan, IICA points out that:

The four major challenges for agriculture in the hemisphere are: 1) being competitive, which will require greater productivity; 2) contributing to the development of rural territories, through the linkage of primary sector activities and agroindustries to providers of inputs and services; 3) conserving natural resources, improving environmental conditions and taking preventive measure to mitigate the impacts of climatic conditions; 4) making a major contribution to food security by increasing the production of safe and more nutritional foods, addressing issues related to the availability of and access to food, on the one hand, and the generation of higher incomes for the rural population on the other (IICA 2010a:20).

The document also states that despite the fact that the hemisphere continues to be a net exporter of foods, one of the most urgent challenges to be faced is to increase productivity through “technological innovation, but increasingly in keeping with environmental demands; in other words, in a sustainable and inclusive manner.”

The Institute expresses its concern for the use of certain inputs that do not improve productivity and have a negative impact on the environment; however, it also highlights the fact that technological innovations have been developed that are based on biotechnology, such as the new genetically improved varieties, organic fertilizers and biological control methods that do have a favorable impact on productivity and the quality of healthier and safer foods. In this regard, it emphatically points out that:

- » The process of change needed in agriculture demands technological innovations such as different biotechnological applications and the incorporation of better agricultural practices accompanied by good agricultural health and post-harvest practices.
- » Also needed are innovative management practices that will lead to arrangements between producers and agroindustries and to new ways of running successful agribusinesses.
- » Of course, it is impossible to overlook problems such as the thousands of poor *campesinos* who have not been able to participate in the innovation process, which they could do using their own knowledge and culture and using the genetic biodiversity of their native products. It is essential to formulate strategies focused on solving the particular problems of the production and marketing systems of the *campesinos* (IICA 2010a:20-21).

The document also states that “the launching of innovation processes aimed at making agriculture more competitive and sustainable, as well as the extension of the benefits to a larger number of people, require a framework of well-articulated policies and their application through the policy tools most suitable for encouraging and providing support for production. As a result, policies and institutional capabilities will have to be renewed” (IICA 2010a:23).

Competitiveness in agriculture continues to be directly associated with policies concerning technology, financing, trade, environment, health, soil use regulations, water, legal security and in general, all of the issues that create a favorable environment for investment and development. As a result, modernizing the institutional framework of agriculture and rural development in the countries of the hemisphere (which is, in most cases, dated) and in institutions in charge of the agricultural sector becomes crucial. This must be carried through actions such as revising and renewing their roles, better preparing their staff and using innovative policy instruments, follow-up and evaluation systems, information systems and a higher number of resources.

The first strategic objective defined in the document, “*To make the agricultural sector more productive and competitive*”, provides that the countries must develop public strategies and encourage the formulation of private strategies to promote innovation, attract investment, reduce the uncertainty in agriculture and develop new business models that will improve its productivity and competitiveness. They will also have to find more balanced trade and market mechanisms. It also points out that:

IICA must promote innovation to enhance competitiveness, increase production and help improve the operation of agricultural markets in a socially and environmentally sustainable way. In these efforts, it is necessary to consider the inclusion of small and medium-scale agricultural producers, who have limited access to modern markets, as well as the development of the markets for the traditional commodities consumed by the people in the lowest-income brackets (IICA 2010a:35).

Strategic Objective 3, *enhancing agriculture’s capacity to mitigate the effects of and adapt to climate change and make better use of natural resources*, provides that:

Agriculture poses two major challenges for the countries in terms of its relationship with the environment. The first concerns innovation - the need to develop technologies, plant varieties, animal species and productive models that reduce the vulnerability of agroecosystems, adapt agriculture to the new climatic conditions, mitigate the activity’s impact on the environment and natural resources and, at the same time, pay proper attention to the growing demands of consumers in these areas (IICA 2010a:37).

Finally, in the section that discusses technical cooperation objectives, the Institute describes innovation as one of the priority areas, stating that:

One of the biggest issues derived from the analysis of the context, and which can be seen clearly in the challenges facing agriculture, is the need to innovate, in all aspects and at all levels of agriculture. This includes the need to develop new plant varieties and animal species adapted to growing, heterogeneous and variable demands; develop and disseminate innovative technologies geared to the needs of businesses; strengthen extension systems, to make them efficient and capable of carrying the new technologies and varieties to producers, especially small-scale ones, protect intellectual property; and develop policies, strategies and new business models. With that purpose in mind, IICA intends to support the institutional efforts of its Member States to increase and extend innovation in agriculture, in order to improve production, competitiveness and trade and thereby support food security and the development of the member countries (IICA 2010a:40).

The document goes on to point out the need to promote multisectoral policies aimed at creating a favorable environment that facilitates access to the productive assets, inputs, technologies and knowledge needed to promote innovation processes in rural territories and the strengthening of family and small-scale agriculture.

The strategic importance of innovation for continental agriculture was established in the 2010-2014 Medium-Term Plan (IICA 2010b), where it was defined as one of the institutional principles. This strategic objective, *to improve the productivity and competitiveness of the agricultural sector*, reads as follows:

IICA intends to promote technological, organizational and human innovation to enhance competitiveness, increase production and help improve the operation of agricultural markets in a socially and environmentally sustainable way. These efforts will also have to include small and medium-scale agricultural producers, who have limited access modern markets (IICA 2010b:18).

As for objectives of technical cooperation, the Plan (IICA 2010b:20) states that “IICA intends to support the institutional efforts of its Member States to increase and

extend innovation in agriculture, in order to improve productivity, competitiveness and trade, and thereby support food security and the development of the member countries”. It also defines four technical concentration programs; the first one is *Innovation for productivity and competitiveness*, the purpose of which is to “improve research, innovation and transfer/technological extension for a more competitive and sustainable agriculture” (IICA 2010b:27).

Within this framework, the Executive Committee (EC), gathered in San José, Costa Rica, between July 12 and 14, 2011, prepared a document entitled *Innovation to achieve competitive, sustainable and inclusive agriculture*, where it highlighted the importance of agricultural innovation in the Americas and defined the Institute’s participation in its development (IICA 2011).

The document states that innovation is key for the American continent to successfully face the challenges that will arise in the short, medium and long terms. One of the most serious challenges facing agriculture is the volatility that has characterized agricultural markets, caused by climate instability and the concentration of agricultural production in only a few countries. In order to address the volatility of agricultural markets,” innovations are needed that make it possible to cover more risks, more information and transparency in the operation of the markets and new instruments for forecasting weather and making financial predictions” (IICA 2011:9). In a globalized society, innovative risk management processes become more relevant than ever before.

Innovation is also essential for agriculture to cope with a roughly 70 % increase in food demand in the near future. One must not forget that agricultural yields have decreased in the past few years, that there is no possibility to extend the arable land and that competition for the use of land (for biofuels, other non-food related uses and urban and industrial developments) is still on the rise (IICA 2011:9).

The negative effects of climate change are becoming increasingly relevant, and this trend will only continue. Agriculture is one of the activities causing climate change and at the same time, one of the most affected by it. This poses a two-fold challenge that involves mitigating changes and adapting to them at the same time.

Innovation can also contribute to overcoming rural poverty and marginalization affecting rural areas in LAC. Small-sized farmers are most vulnerable to market volatility and must face major obstacles to access markets and increase their farms' productivity.

Lastly, it is important to mention the challenge of incorporating the region into the production of food with greater value added. Although some countries in the region have managed to do this, the region still lags behind (IICA 2011:10).

The document prepared by the Executive Committee states that innovations are not neutral. They can bring about environmentally-sustainable growth in production or the deterioration and degradation of natural processes. Similarly, innovations can lead to the integration small farmers and women, or cause them to lag behind or be excluded altogether. It is therefore important to develop innovations and promote the sustainable and responsible use of natural resources and social inclusion through, for example, concepts such as good agricultural practices, good energy use practices, animal well-being and social responsibility among businesses. The ultimate goal is to boost productivity, sustainability, inclusiveness and competitiveness:

A New Agricultural Revolution is needed, one very different in terms of its challenges and technological and organizational paradigm from the Green Revolution of the 1960s and 1970s. The key technological challenge of the new agriculture is to produce more and better foodstuffs and non-food agricultural products through productive processes that generate fewer greenhouse gases, make more efficient use of water, utilize basically the same surface area and can cope with the new biotic and abiotic stresses caused by climate change, while at the same time allowing society to monitor the technologies used more closely. All these restrictions and requirements were practically non-existent at the time of the Green Revolution. Innovations unquestionably have a key role to play in each of these areas (IICA 2011:12).

In order to achieve this, the document points out that at least four key elements must be considered: 1) a policy that must be the right one, and availability of the public and private resources required to implement it; 2) an environment of economic and business flexibility; 3) suitable mechanisms must be created to take advantage of the

technological advances and innovations that become available around the world, such as the establishment of partnerships, the implementation of technology surveillance mechanisms and the development of regional integration mechanisms; 4) national agrifood innovation systems must be developed, with clear governance and sufficiently linked to national innovation systems.

Strengthening the NARIs, increasing investments in research and development, renewing and/or updating the expertise of key scientific staff, modernizing the laboratory infrastructure and promoting partnerships between the public and the private sectors are also essential steps that need to be taken.

The EC goes on to highlight the role of IICA in the creation of the Hemispheric System for Technology and Innovation, promoting the development of collaborative technology integration programs such as the PROCIs, FORAGRO and FONTAGRO as well as the development of NARIs and national agrifood systems. The Institute has focused on providing support for small- and medium-scale producers and broadening its actions to incorporate innovations into the different links of agrifood chains.

In this sense, it works with the countries to modernize the institutional framework, develop national capabilities, manage and disseminate knowledge, and support the formulation and implementation of investment projects designed to promote innovation. In the 2010-2020 Strategic Plan and in the 2010-2014 Medium-Term Plan, IICA defined the following priorities in terms of institutional innovation: promoting regulations that adequately protect technologies, products, processes and plant genetic resources through the management of intellectual property; fostering the harmonization of standards in the area of biosafety and organic production; and facilitating effective interaction and the development of common agendas among the different stakeholders in national agrifood innovation systems.

In the field of innovation in organizations and businesses, IICA is supporting the development of networks and partnerships between innovation systems and enabling the development of new types of associative arrangements for producers. In the field of technological innovation, it has helped the ministries of agriculture with the development of standards for the biosafety protocols, supporting the development

and application of technologies and good practices to mitigate and adapt agriculture in the hemisphere to climate change. Likewise, it has fostered the diversification of production to help achieve food security, promoting the revamping of extension systems, supporting the development of national agrifood innovation systems and the modernization of the NARIs, helping to strengthen and renew FORAGRO, FONTAGRO and the PROCl. Across these overarching fields, IICA aims to promote actions aimed at improving the use of information and communication technologies (IICA 2011:14-15).

Based on these guidelines, the ministers and secretaries of agriculture of the Americas came together in San José, Costa Rica, between the 19th and the 21st of October 2011, with the motto “Sowing innovation to harvest prosperity”. The purpose of this meeting was to engage in dialogue and adopt commitments to advance food security, rural well-being and the development of a competitive, sustainable, inclusive agrifood sector. Below is a transcription (except for point 1) of the ministerial declaration that resulted from said meeting:

[...]

2. *Agreeing that agricultural innovation is a catalyst for growth and positive change, and further, to foster innovation it is vital to increase and intensify production and productivity, improve incomes, reduce poverty and inequality, decrease the environmental impacts of the agrifood sector, respond to natural disasters, increase access to new technologies, adapt to climate change and, consequently, achieve food security and a better quality of life for all our citizens.*
3. *Recognizing that innovation in the agrifood sector should include: better practices and new technologies, wholesome and safe products, better infrastructure to support production and marketing, technology transfer, sharing knowledge and building relationships through value chains, training and extension services, access to credit, and a science-based legal and policy framework.*
4. *Being aware that to meet today’s challenges and preparing for the future, requires the promotion of innovation in the agrifood sector throughout our hemisphere, in order to achieve food security and sustainability of natural resources, taking into account the rising demand, climate change, high input costs, and resource constraint.*

Do hereby declare that:

5. *The agrifood sector and rural development play a fundamental role in the overall development of all the countries of this hemisphere to achieve the economic and social growth of the inhabitants of the Americas.*
6. *Effective access to innovation and technology transfer is a key element to achieve a sustainable, competitive and inclusive agrifood sector.*
7. *Innovation will assist the agrifood sector to address economic and environmental challenges and offer tools for converting the sector into an axis for economic and social development.*
8. *Adoption of public policies and transparent regulatory systems to promote and support innovation in the agrifood sector is fundamental to achieving the development and use of innovative agricultural technologies and practices and the objectives of competitiveness and economic growth, with social integration, in each of our countries.*
9. *The use of science-based technical regulations and sanitary and phytosanitary measures, while not unduly restricting national and international trade, is key to enabling countries to benefit from innovative agricultural technologies.*
10. *The regional, hemispheric and global initiatives with respect to innovation are an excellent complement to the efforts that each of our countries is deploying and will therefore be the priority areas for joint action.*
11. *The support of regional and international bodies for technical cooperation and agrifood development funding is essential to achieve the common objectives that the countries have established for strengthening national innovation systems, built on different types of cooperation.*
12. *The Inter-American Institute for Cooperation on Agriculture (IICA) serves a leadership role in supporting innovation for the competitive and sustainable*

development of the agrifood sector in the Americas and for improving rural life through the provision of technical cooperation, the dissemination and leveraging of its specialized knowledge and its networks of experts, implementing projects, and working with its Member States.

For these reasons, we urge:

13. *The Member States, the international funding and cooperation agencies, and public and private sector organizations, to strengthen the institutional frameworks and increase investment and financing of agrifood innovation systems in a sustainable and predictable manner, with measurable results.*
14. *The international organizations which operate within the hemisphere, the national agencies for international cooperation, the national governments, the research centers and regional agrifood research and innovation mechanisms, to cooperate mutually on behalf of the countries and to develop a regional strategy to promote innovation, transfer and access to these technologies.*

We commit to:

15. *Promoting, with the assistance of the public and private sector, a greater role for research and the development and transfer of knowledge for the agrifood sector in national innovation systems, as well as the access to technology and capacity building for small scale producers.*
16. *Adopting public innovation policies in the agrifood sector, strengthening the creation and improvement of public and private organizations with responsibility in this area and encouraging their effective and committed participation.*
17. *Developing national strategies for the development, dissemination and use of innovation, including agrobiotechnology, nanotechnology and information and communication technologies, in accordance with the policies of each country, that support and guide all efforts geared at improving competitiveness of the agrifood sector value chain, preserving natural resources and promoting social integration, value added at country of origin and the full development of its productive capacity.*

18. *Promoting innovations by strengthening science-based risk assessments, sanitary and phytosanitary measures, and technical regulations as key elements for allowing countries to benefit from better access to markets of agrifood products.*
19. *Establishing favorable conditions and mechanisms for promoting a culture of innovation based on strategic alliances for collaborative work among public and private organizations, at the national and international levels, North-North, South-South and triangularly, in order to develop, transfer and implement innovative practices and technologies, oriented towards agricultural productivity and sustainability of the agrifood sector.*
20. *Strengthening the monitoring and early-warning systems on food security and improve the availability of timely and reliable market information to foster market transparency and identify commercial opportunities for agrifood products.*
21. *Supporting the work of the Market Information Organization of the Americas (MIOA) to promote greater collaboration between the Member States on innovative means to collect, process, analyze and disseminate information relative to markets and agrifood commodities fostering greater market transparency and efficiencies.*
22. *Promoting sustainable direct investment in the generation of new knowledge and the strengthening of extension systems to ensure its transmission through innovative methodologies.*
23. *Supporting technological and institutional innovations that: (i) facilitate greater integration of the agrifood sector – including small scale producers–in the value chains, (ii) strengthen the links between the traditional agrifood sectors with the “intensive knowledge” sectors, (iii) strengthen the technological base to undertake competitive activities, and (iv) facilitate rural social integration.*
24. *Fostering innovation, including land and water management technologies, biotechnology and all other factors that contribute to the resilience of agrifood production systems in the face of adverse climate events.*

25. *Stimulating innovation in different types of agroenergy that contribute to the diversification of the energy matrix and the reduction of negative environmental impacts.*
26. *Promoting innovation in climate risk management and fostering national, regional and hemispheric initiatives as well as facilitating the identification and dissemination of best practices that reduce the vulnerability of the agrifood sector and of the rural milieu.*
27. *Investing in the improvement of appropriate capacities and skills of our human resources to foster research and innovation as well as promote agrifood entrepreneurship.*
28. *Continuing support of IICA in its capacity of working jointly with member countries, to help foster innovation in the agrifood sector consistent with this Declaration (Declaration of the Ministers of Agriculture, San José, 2011).*

In the 2014-2018 Medium-Term Plan, IICA renews its vision as a provider of cooperation services at the hemispheric, regional, plurinational and national levels, tapping into its competitive and comparative advantages. It also decides to adopt a “results-based management” so that technical cooperation not only can contribute to the fulfillment of the four strategic objectives in the region, but also to help Member States achieve sustainability, competitiveness, rural well-being and food security. The section “About innovation” points out that:

- » *We live in the “age of innovation” associated with such concepts as changing, exploring, salvaging, inventing, reinventing, creating, risking and managing opportunities. Innovation is a transformative process that broadens the horizon of possibilities for a company, productive sector or country. Innovations are the force that continually drives growth for countries, and one of the essential strategies for modern societies to maintain their competitive edge.*
- » *Agricultural innovation is a catalyst for growth and positive change. Promoting innovation is vitally important to increase productivity and competitiveness,*

boost income, reduce poverty and inequality, lessen the environmental impact of the agricultural sector, respond to natural disasters, broaden access to new technologies, adapt to climate change and, consequently, achieve food security and the best possible quality of life for our peoples.

- » *Agriculture needs a wide-ranging process of innovation that will develop new production, institutional, organizational and knowledge paradigms for meeting the challenges of competitiveness, inclusion and sustainability.*
- » *Countries hoping to induce processes of innovation in agriculture must provide a favorable environment that includes coordinated policies, rigorously applied by means of instruments to encourage production, develop a critical mass for research and development, strengthen innovation systems, attract investments and develop new business models in agriculture.*
- » *The potential to innovate can be put to use primarily in three areas: (a) technology (including extension and communication), to boost productive capacity, (b) markets, to boost competitiveness, and (c) institutions, to improve governance.*
- » *Innovation in agriculture develops best through national agrifood innovation systems, especially if these systems work in coordination with one another through other regional or hemispheric platforms. To strengthen such systems, to promote technology transfer under mutually agreed terms and to share knowledge and good practices should be high priority tasks for governments and for society.*
- » *Innovation in general, and the processes that trigger it, do not simply appear out of nowhere or spring from decisions based on goodwill; innovation takes place in a given socioeconomic context and reacts to the presence (or absence) of favorable conditions that allow it to prosper, including most particularly, sufficient domestic development, institutional and regulatory frameworks, a reservoir of knowledge and human skills, a society that is calling out for innovation, and a welcoming regional and global environment. The challenge for agriculture, therefore, is to unleash and strengthen intensive, lasting processes of innovation and virtuous circles of innovation with the participation of all stakeholders (IICA 2014:12-13).*

Innovation is an undisputable part of IICA's strategic objectives:

Strategic objective 1: *To improve the productivity and competitiveness of the agricultural sector.*

The Institute will support its Member States in: a) building, strengthening and managing agricultural innovation systems, including the development of productive, organizational and business solutions [...]

Strategic objective 3: *To improve agriculture's capacity to mitigate and adapt to climate change and make better use of natural resources. In order to develop a sustainable agriculture, IICA will support its member countries in [...]*

b) increasing and improving the capacity of innovation systems to develop practices and materials that facilitate the efficient adaptation of agriculture to climate change and the development and application of technologies and processes to reduce the impacts of agriculture on the climate and on natural resources [...]

Strategic objective 4: *To improve agriculture's contribution to food security. In order to add value to the different initiatives aimed at resolving the problem of food and nutritional insecurity, IICA will promote ... b) innovation as a means to boost productivity and competitiveness as central elements of food and nutritional security [...]* (IICA 2014:21-22).

In this sense, the expected transformations in the countries as a result of technical cooperation are:

Increased level of adoption and dissemination of innovative practices, as well as sustainable processes and technologies that optimize the sustainable productivity of agricultural and agrifood systems (IICA 2014:24).

In order to reach these goals, IICA made a commitment to make eleven major contributions including:

Implementing, through public and private institutions, technological, institutional and business innovations aimed at boosting the productivity and competitiveness of agriculture and the production of basic foodstuffs of high nutritional quality (IICA 2014:25).

Furthermore, the Institute has made a decision to contribute to the capacity strengthening of public and private stakeholders, among others, associated with agricultural innovation systems. It has also decided to promote innovation for processes and products in order to strengthen agricultural chains and rural territories and encourage the use of good agricultural practice.

In the plan, the Institute defined the priorities for the 2014-2018 period:

Considering the technical cooperation agenda proposed and recognizing the importance of family agriculture, women and youth for the future of agriculture and the crosscutting nature of the mandates received by IICA at the last two ministerial meetings with respect to the topics of innovation and water resources management, the Institute will focus on an integrated, systemic approach in all of its actions, initiatives and projects.

Specifically, IICA will promote and facilitate processes that lead to a systemic culture of innovation in agriculture. Therefore, IICA's efforts will focus on ensuring that its member countries, producers and relevant stakeholders have access to data, information, knowledge (scientific and empirical), good practices and innovations that can be used to transform their productive and business processes, or those of any other nature, such as biotechnology, nanotechnology, precision agriculture, geomatics and informatics, among others. Similarly, the Institute will work to develop capabilities and create scenarios for innovation, facilitating and promoting coordination processes between producers and research centers that generate knowledge and technologies, including those within the private and the public sectors (IICA 2014:29).

PRINCIPAL ACTIONS AND INNOVATION PROJECTS PROMOTED BY IICA

At the Meeting of Ministers of Agriculture of the Americas, held from October 19 to 21, 2011 in San José, Costa Rica, under the theme of “*Sowing innovation to harvest prosperity*”, IICA’s 1942 mandate of encouraging, promoting and supporting the efforts of its member countries in order to achieve agricultural development and rural well-being, was once again renewed.

In consideration of that year’s mandate, IICA made significant changes to its technical cooperation model, especially those aspects that focused on the formulation of IICA-country strategies, which try to respond effectively to the demands of the countries of the continent. The Institute’s six cooperation programs –technological innovation, promotion of agribusinesses, strengthening of agricultural health, development of rural territories, food security and climate change–continued to carry out their lines of action in response to the countries’ defined priorities. They also continued to support the national, regional, and hemispheric projects, and implemented a fund to boost multinational innovation projects.

In order to promote technological innovation, diagnostic and institutional development instruments for improving the national research systems were developed and the strengthening of regional integration mechanisms for research, as well as capacities for innovation in Bolivia, Uruguay, Peru, Costa Rica, Paraguay, and Ecuador, among other countries, were boosted. Additionally, new mechanisms of hemispheric scope for the exchange of knowledge were developed, especially the Management Network for Innovation in the Agri-food Sector (INNOVAGRO Network), in which 50 public, private, and academic institutions (IICA 2012:1-4) participate.

During 2011, IICA fostered technological innovations and organizations that helped to promote competitiveness and productivity, as well as a better operation of regional agricultural markets. The strengthening of capacities for the innovation of human resources in the agricultural sector in member countries, was also promoted.

Regional and international cooperation for technological innovation

IICA participates considerably in the Forum for the Americas on Agricultural Research and Technology Development (FORAGRO) and in the Regional Fund for Agricultural Technology (FONTAGRO), where agendas of hemispheric work in relation to research and innovation are developed. In 2011, new platforms in the Cooperative Program for the Development of the Agrifood and Agroindustry Technology in the Southern Cone (PROCISUR) were established. Projects that resulted in technological improvements in the corn and bean production systems were also implemented, and the linkage of researchers and access to technologies was promoted through the Central American Integration System for Agricultural Technology (SICTA) (now Transfer and Research Technical Group). Within the framework of the Cooperative Program on Research and Technology in the Northern Region (PROCINORTE), the national systems of genetic resources were strengthened, evaluation studies of the physiological maturity of mango and avocado were continued, as well as research in invasive pathogenic plants, pesticides, seeds, H1N1 influenza, and other epizootics.

IICA also participated in the formulation and negotiation of programs and innovation projects, such as the Humid Tropics Program of SAGARPA in Mexico, in order to improve the competitiveness of agricultural products in the states of Tabasco

and Chiapas; in the comparative study of genetically modified soybeans, in Argentina, Brazil, Paraguay, and Uruguay; in the strengthening of the Sugar Industry Research and Development Institute of Belize, and in the project for the National Reference and Ovine Genetic Development Center of the GDI-INTECH of Argentina.

A partnership forged with the Brazilian Agricultural Research Corporation (EMBRAPA) made it possible for IICA to consolidate several programs, among them, the Cooperative Program for Research, Development, and Agricultural Innovation for the South American Tropics (PROCITROPICOS) and PROCISUR, in addition to being linked to projects such as AGROFUTURO and EMBRAPA Americas (IICA 2012:8-9).

National innovation systems

In 2011, IICA developed instruments for the diagnosis and institutional strengthening of the national agricultural innovation systems (SisNIA) and the national agricultural research institutes (INIA) of countries in the region. Among the Institute's collaborative actions, the support offered to Bolivia's National Institute for Agricultural and Forest Innovation (INIAF) to boost the capacities of the national innovation system and formulate research projects under strategic categories, were highlighted; to Uruguay's Livestock National Research Institute (INIA) to evaluate the economic, environmental, and social impact of its research; to Peru's National Institute of Agrarian Innovation (INIA) to identify institutional limitations in the area of technological innovation, solve any problems found, and prioritize technological demands; to Ecuador's National Autonomous Institute for Agricultural Research (INIAP) to promote the renewal and strengthening of the laboratory network of the Amazon region's new experimental station; to Costa Rica's National Institute of Innovation and Transfer of Agricultural Technology (INTA) to formulate institutional modernization proposals, and to the Paraguayan Institute of Agricultural Technology (IPTA) to develop institutional management strategies and improvement of its capacities in this area. Furthermore, after several training workshops on communication processes and distance learning, it was possible to strengthen Panama's Integrated System of Livestock Extension (SIDEA) (IICA 2012:10).

Furthermore, IICA prepared Methodological Guidelines for the Diagnosis of National Food and Agriculture Innovation Systems in LAC, to help the member countries to

promote and consolidate their SisNIA. The purpose of this guide was to facilitate the assessment realization of the structure and characteristics of these systems and support decision-making with respect to innovation policies. Through a series of indicators and measurements, the guide made it possible to characterize the productive as well as science and technology systems; the stakeholders within the system and their roles; the institutions within the system; and develop an analytical framework that integrated those three aforementioned points (linchpins). In that way, a comprehensive situational assessment (IICA and INNOVAGRO 2012) could be obtained.

Knowledge Management and Information and Communication Technologies

In 2011 IICA, together with the National Coordinator of the Produce Foundations (COFUPRO) of Mexico, supported the creation of the Network for the Management of Innovation in the Agrifood Sector (INNOVAGRO). The purpose of this network is to contribute to the region's food and agriculture development through mechanisms of cooperation and strategic partnerships with regard to innovation and innovation management. Institutes for innovation and agricultural research, foundations, funds for agricultural innovation, producers' organizations, universities and other institutions within the public, private and academic sectors of Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, El Salvador, the Netherlands, Spain, Guatemala, Mexico, Nicaragua, Peru and the Dominican Republic participate in it.

That year, in a workshop organized in Brazil by IICA, FORAGRO, EMBRAPA, the International Center for Tropical Agriculture (CIAT), and FAO, the Platform for the Development of Knowledge Management Capabilities (KM) for Innovation was launched. The topics to which this platform would pay attention were also defined: policy-making and institutional strategies for KM, the use of KM methods and tools and the utilization of information technology and communication (ICT) (IICA 2012:10).

From its origins in 1942, IICA has been a valuable source of information through its knowledge repositories and libraries. Definitely, one of the hemisphere's first agricultural libraries still in-service is the Orton Commemorative Library, located on the CATIE campus.

In more recent times, two important digital efforts have been consolidated as a means of bringing scientists together, to provide knowledge and protect the region's agricultural memory: i) The Alliance of Agricultural Information Services (SIDALC), which brings together 175 national institutions in 22 countries and which, each year, facilitates access to 3 million references and to 238,095 documents (full texts). The website www.sidalc.net, whose content is distributed in 345 databases, is visited on average by more than 3 million users and its network of libraries shares nearly 60 thousand scientific/technical articles annually, a management that represents mobilization of resources of more than two million dollars; ii) The other virtual platform is AGRIPERFILES, (<http://agriperfiles.agri-d.net/>) which stores 2,054 professional profiles related to more than 1,762 organizations worldwide.

Finally, and to the extent that the countries have required it, it has provided support in the promotion of solutions associated with precision farming, the use of geographic information systems, mobile telephony and drones. In 2016, IICA developed four experiments in the use of text messaging services and mobile telephones in the agricultural markets of Costa Rica, Ecuador, Trinidad, and Uruguay.

Principal activities and projects advanced between 2012 and 2015

In 2012, the principal activities of IICA were geared towards supporting its Member States with new or up-to-date instruments destined to modernize their national innovation systems. In El Salvador, Nicaragua, Costa Rica, Uruguay, Paraguay, Peru, Bolivia, and Mexico, the capacities for institutional development and policy-making for agricultural innovation were reviewed. In addition, through the Observatory of Institutional Innovations and the Management Network for Innovation in the Agrifood sector (INNOVAGRO Network), IICA shared nearly 50 innovation experiments and systematized 4 institutional research models. The effort of the Institute made it possible to generate innovations in the Caribbean in the areas of agribusiness, greenhouse production, and the breeding of small ruminants. In Central America, 4 projects were implemented with financial support from the Inter-American Development Bank, the Swiss Agency for Development and Cooperation (COSUDE), the European Union and Korea, in which the SICTA-COSUDE Network project was highlighted, with which success was achieved in duplicating the bean production of

30 organizations of Nicaraguan producers and increasing corn and bean productivity by 30 %, in addition to reducing the costs of postharvest management in the district of Toledo, Belize. In that country, a project was started to support the Sugar Industry Research and Development Institute (SIRDI). That project relies on financing from the European Union and seeks to transfer improved technologies to sugarcane producers and offer them extension services.

A good example of the actions undertaken by IICA was the application of the model for agricultural innovation that was used in the Family Farm Plan (PAF) of El Salvador's Ministry of Agriculture and Livestock (MAG), specifically in the PAF Program –Productive Chains. Nearly 16,000 producers benefited from this model through methodologies and tools for production, associativity, marketing, and institution building.

Other achievements that were reached in innovation in 2012 were:

In Antigua and Barbuda the technology of low-cost bio-digesters was introduced to pig farmers and it helped breeders and technical livestock personnel to improve their organization, management and productivity. In Bolivia there was cooperation with the National Institute of Livestock and Forest Innovation to form the Network for Genetic Improvement of Dairy Cattle in the Bolivian Highlands. In Chile, a comparative study on institutional experiences in gene bank management in Brazil, Argentina, Costa Rica, Mexico, and New Zealand was conducted, that was then used as a guide for modernizing the Chilean institutional framework in charge of carrying out practices in that area. In the Dominican Republic, producers were trained in intensive silvopastoral systems. And in Saint Kitts and Nevis, the Institute, in collaboration with the Caribbean Agricultural Research and Development Institute (CARDI), made it possible for farmers and producers to strengthen their capacities in root and tuber processing.

Included among the projects of the Competitive Fund for Technical Cooperation approved in 2012, are that of “Agricultural innovation for the sustainability of the biodiesel and bio kerosene value chain”, in which Brazil, Colombia and Mexico participate, and the “Competitive Innovation Fund for agriculture and food security in the Americas”, a hemispheric project, formulated for the Foundation Howard G. Buffet (IICA 2013a).

In 2013, in IICA's annual report, the Director-General, Dr. Víctor M. Villalobos pointed out that one of the principal achievements of the Institute had been to place the concept of innovation at the center of the actions, as a means of constructing a new agricultural paradigm. Among the principal contributions of the Institute in this matter, the following are mentioned (IICA 2014:vii-ix and IICA 2013:vii-ix):

- ➔ *The Hemispheric Agricultural Innovation System was revitalized with the creation of public-private consortia and innovation networks operating at the regional level. In addition, innovative technologies were developed to benefit producers, enabling countries to improve their genetic materials and increase the supply to markets.*
- ➔ *More than 2400 members of the national innovation systems in countries of the South American tropics and the Caribbean had access to the results of studies and to technological advances achieved in the context of various regional networks and through efforts undertaken with international research centers.*
- ➔ *IICA supported legal and regulatory innovations, established intersectoral arrangements and implemented institutional management models adapted to the specific needs of different rural territories. It also strengthened the management capabilities of more than 1100 leaders of public institutions, local governments and other organizations in 13 countries, using the area-based (territorial) approach.*
- ➔ *IICA implemented innovation strategies and extension services aimed at reducing hunger, including the National Crusade Against Hunger (Mexico) and the Zero Hunger Challenge (Antigua and Barbuda).*

Moreover, within the framework of the Regional Program for Research and Innovation by Agricultural Value Chains (PRIICA-European Union), small Central American producers included in 24 public-private local innovation consortia formulated projects for generating and validating technology and strategic innovation plans. Additionally, networks for the regional avocado, cassava, potato, and tomato chains were organized, and a regional research and innovation agenda was prepared and evaluated for each of those products.

In Central America, the project Agricultural Innovation Network (SICTA-COSUDE Network) benefited 28 600 small producers with 29 innovative technologies for the different links of the corn and bean chains. These technologies were disseminated

through 30 projects undertaken through partnerships among the members of that region's technological innovation networks; likewise, 115 organizations and institutions from Nicaragua, Honduras, Guatemala, Panama, and El Salvador participated in 5 national technological innovation networks in corn and beans, while 313 organizations from different sectors were integrated in 16 territorial networks for technological innovation.

Other achievements in agricultural innovation were (IICA 2014:3-7) as follows:

- ➔ Improvement of the genetic material of the sweet pepper used by producers in Costa Rica's west central valley, an action that was brought about thanks to a consortium between the Institute for Innovation and Transfer of Agricultural Technology (INTA), the University of Costa Rica (UCR), the Ministry of Agriculture and Livestock (MAG), and organizations of producers. That is supported by IICA within the "technological innovation strategy to improve the productivity and competitiveness of product chains in Central America and the Dominican Republic" project (PRESICA);
- ➔ Supply of pure pine nut oil to the Floreana Island, in Ecuador, through the project "Pine Nut for the Galapagos Islands";
- ➔ Production of high nutritional content and low cost forage in Paraguay, jointly with the Autonomous University of Asunción;
- ➔ Creation of the area-based brands "Norticos" and "Brunca" as marketing innovations, for the bean producers' families in Costa Rica (SICTA-COSUDE Network);
- ➔ Establishment of a Green Fund for the production of aircraft fuel by family farmers in seven countries of Latin America and the Caribbean, within the framework of the Flying Green program of the Brazil 2014 World Cup Football and the 2016 Olympic Games in Rio de Janeiro;
- ➔ Launch of the Central American Initiative on Biotechnology and Biosafety (ICABB) the objective of which is to promote the use of biotechnology and foster organic agriculture. More than 2,400 members of the national innovation systems of the countries of the South American tropics had access to results of research conducted by various regional networks for research, development and innovation in areas such as cacao, coffee, agro energy, animal production, aquiculture, genetic resources (Tropigen), to agricultural, forestry and livestock systems (AFP) and to

the Amazon initiative. The dissemination of this information was the responsibility of the Cooperative Program for Research, Development, and Agricultural Innovation for the South American Tropics (PROCITRÓPICOS), which held forums and distributed bulletins such as InfoPROCITRÓPICOS and ProciNOTICIAS.

In the Caribbean, access to technological advances was improved and manuals on the production and germplasm of citrus fruits, rice, potato, and other roots and tubers were prepared, thanks to links established with the Brazilian Agricultural Research Corporation (EMBRAPA), the National Agricultural Research Institute (INIA) of Uruguay, the International Potato Center (CIP), and the International Center for Tropical Agriculture (CIAT).

In 2014, IICA continued to develop substantive tasks in order to promote cooperation among the countries of the Americas and make agriculture on the continent a more competitive, productive, and sustainable activity that successfully meets the challenges of adapting agriculture to climate change, halting rural-urban migration, the aging of rural farmers and technical personnel, and combatting social exclusion and low investment in innovation. In accordance with IICA's 2014 Annual Report, that year:

Thousands of producers benefited from technological innovations and knowledge related to the production of renewable energies, forest byproducts, sugar, corn, beans, cassava, avocados, potatoes, and tomatoes under projects financed with resources from the European Union (EU), Switzerland, Finland, and the United States. Thanks to IICA's technical cooperation, progress was also made with innovations in quinoa, rice, cacao, sweet potato, Jatropha oil, greenhouse crops, stock farming, bioinputs, and biogas, among others (IICA 2015:vii).

And among the innovations in products and processes that were derived from technical cooperation the document the following is noteworthy (IICA 2015:5-7):

Avocados: Under the Cooperative Program for Technology Research and Transfer for the Northern Region (PROCINORTE), Canadian, Mexican, and U.S. researchers undertook joint research in order to generate a new prototype for measuring the firmness of avocados without damaging the fruit.

Rice: IICA promoted the adoption of the Intensive Rice-growing System in the Dominican Republic. It also collaborated in the design and management of resources for new projects of the Regional Fund for Agricultural Technology (FONTAGRO).

Sugar: With financial assistance from the EU and cooperation from IICA, the Ministry of Agriculture and Natural Resources of Belize trained technical officers of various institutions in the sugarcane industry in research techniques, and 1200 sugarcane producers in good agricultural practices (GAP). In addition, the Institute drafted a medium-term plan for sugarcane research and development in Belize aimed at increasing productivity and competitiveness.

Forests: In the Andean region, the Sustainable Forestry Management Program, which is being implemented with financing from the Government of Finland, devised innovative solutions for the management of natural and plantation forests, and to raise the incomes of farmers who extract natural products from the forest. In Peru, more than 3500 people participated in technical events related to forest innovations.

Cacao: Under the projects financed by the Government of Finland in communities in the north of La Paz and Beni, in Bolivia, the quality of wild cacao beans was improved through the use of clean energy in postharvest systems.

Citrus fruits and mangoes: IICA trained producers in Nickerie, in Suriname, in the production and selection of grafts and pruning techniques for mangoes and citrus fruits.

Bioinputs: Tools were designed for studying the subsector of bioinputs for agriculture, including methodologies for drawing up agendas in Argentina and Nicaragua. With the collaboration of the Paraguayan Agricultural Technology Institute (IPTA) and the Ministry of Agriculture and Livestock (MAG), *Trichoderma* bioinputs were produced for disease control and *Beauveria* for pest control. The distribution of these bioinputs among the country's agricultural sector led to a reduction in the use of agrochemicals.

Biogas: With the collaboration of 60 representatives of the public and private sectors of 17 LAC countries, draft guidelines were prepared for differentiated policies and orientations for biogas programs for family farming. With financial support from Finland, 2 three innovation projects involving the use of biomass and organic waste were implemented in Colombia, while two micro hydro systems were set up in Cocapata and Pucarani, in Bolivia. In Guyana, biogas systems were installed at the School of

Agriculture and the Ministry of Agriculture, and 25 livestock farmers received training in the systems' use and adopted the technology to reduce environmental pollution.

Livestock farming: Through the application of the South-South cooperation approach, the Uruguay's experience with the cattle traceability system was made known to the delegates of fifteen LAC countries.

Greenhouses: In Guyana, five demonstration greenhouses were set up for vegetable production and their impact increased with training for 200 farmers in new production methods, provided by Partners of the Americas and other organizations. In Bahamas, the Institute improved the use of water and the diversification of production by 20 farmers who work with greenhouses; in Antigua and Barbuda, IICA supported the efforts of Mexican engineers to conduct studies on protected agriculture; and in St. Kitts and Nevis, 75 women and young people increased their productive capacity through training in the use of greenhouse technologies.

Dairy products: Under the Government of El Salvador's Family Agriculture Plan (PAF), IICA supported the efforts to provide at least 1500 livestock producers with the equipment, infrastructure, and expertise required for the hygienic production, storage, and processing of milk.

Corn and beans: The Agricultural Innovation Network (Red SICTA) project that IICA is implementing in Central America with financial support from the Swiss Agency for Development and Cooperation (COSUDE) benefited 101,207 producers (29 % women and 71 % men). As many as 81,671 were sensitized to innovative technologies and 19,536 adopted them (pre-drying techniques, improved varieties, machinery, microorganisms and inoculants, among others). Some 52 % of the users of such technologies managed to raise their income by more than 15 %; and the families that used innovative technologies had 18 % more food available compared with the years prior to the implementation of the project. In Haiti, through the centers for the production of quality seeds established in Mirebalais, Gonaives, and Grand Goave, bean production in some areas rose by up to 15 %, thanks to financial support from the U.S. Agency for International Development (USAID).

Potatoes: In Jamaica and Saint Kitts and Nevis, 90 public and private stakeholders boosted their capacities for innovation in order to promote greater productivity and sustainability by means of good production practices in the potato chain (Beauregard

variety). In Nicaragua, within the framework of the Regional Program for Research and Innovation in Agricultural Value Chains (PRIICA), a joint program of the European Union and IICA, the Karú variety, which is resistant to some of the principal diseases and has attractive commercial and consumption qualities, was validated. In Honduras a mobile glue trap for control of *Liriomyza* sp. was validated.

Jatropha: IICA contributed so that on the Floreana Island, located in the Galapagos archipelago, Ecuador, 30 000 liters of pure vegetable *Jatropha curcas* oil was produced annually, which in turn was used as biofuel to generate electric power. This facilitated a change in the energy matrix in Galapagos.

Quinoa: With IICA's support, Peru's Center for Research on Natural Resources and Environment and other Peruvian and Bolivian research institutes implemented the project, "Competitiveness of the quinoa value chain in Peru and Bolivia," financed by FONTAGRO.

Cassava: Through PRIICA (EU-IICA), it was possible to validate the ICTA Izabal variety of cassava among producers in Chiquimula, Guatemala. This product presents high yields, adapts well, and is well received for its culinary qualities. In Trinidad and Tobago, IICA conducted studies on the production costs of three types of cassava that will permit the intervention of public institutions in that crop's industry.

In 2015, IICA's activities were geared toward consolidating the new technical cooperation model "designed to deliver impactful results to the countries and, in particular, to bring about the transformations needed to achieve productive, sustainable and inclusive agriculture" (IICA 2016:v).

Among the principal achievements of that year with respect to technological and institutional innovation, IICA's 2015 Annual Report points out the following (IICA 2016:vii):

- ➔ Assessment, design, and formulation of policies and strategies for agricultural and rural development, aimed at facilitating business activities and promoting innovation, participatory management, inclusion, and family farming.
- ➔ Promotion of technological and commercial innovations aimed at improving agroecological production, agroindustry, fish farming, beekeeping, and water

resource management, and reducing food loss. The improvements adopted can be seen in products such as rice, vegetables, poultry, cacao, coffee, flowers, avocados, tomatoes, potatoes, and cassava.

And it specifically points out (IICA 2016:5-8):

National innovation systems: With cooperation from IICA, strategic frames of reference were designed in support of the inter-American scientific institutional framework. The beneficiaries included Ecuador's National Agricultural Innovation System, Haiti's Research Consortium for Agricultural Development, and Costa Rica's National Institute for Agricultural Innovation and Transfer.

Innovative projects in Central and South America: IICA and the IDB supported the 2015 call for bids of the Regional Fund for Agricultural Technology (FONTAGRO) for the presentation of innovations directed at achieving sustainable management of natural resources in family farming in LAC. 146 project profiles were received, 17 were invited to submit final proposals, and 4 were approved by the Fund's Board of Directors. The projects financed were:

- ➔ Centers for the supply of traditional seed varieties (Chile, Argentina, Paraguay and Uruguay).
- ➔ Technological innovations to construct resilient livelihoods among rural families in the Dry Corridor (Nicaragua and Honduras).
- ➔ Innovation platform for the sustainability of family livestock systems in Uruguay and Argentina.
- ➔ Bio-intensive cultivation for rural families in the Dry Corridor (Nicaragua and Honduras).

Innovative policy instruments: After analyzing the experiences of the United States, Brazil, Canada, Central America, China, Chile, and the European Union, more than 3000 public and private stakeholders from 28 member countries of IICA obtained knowledge in policy management for agriculture (trends, challenges, opportunities). Emphasis was placed on policy innovations for more-market oriented agriculture, risk management, regional integration, sustainable management of natural resources and efficient use production inputs.

Innovation and chains: The capacities of 900 public and private stakeholders in 11 agricultural chains were strengthened: cashew (Honduras), fruit trees (El Salvador), cacao and coffee (Panama and Peru), poultry farming (Venezuela), horticulture (Argentina), cattle rearing (Uruguay), ovine and flower growing (Paraguay), goat milk (Trinidad and Tobago) and sweet potato (Jamaica). Technological options aimed at generating innovations in agro-ecological production, use of bio-inputs, product quality, pest control, food loss reduction and water footprint calculation were studied.

Innovation and family agriculture: The Institute boosted the capacities of over 1000 technical personnel and family farming leaders in order to apply productive innovation strategies, as well as strategies for extension, leadership and commercial inclusion mechanisms. Such actions were reached through:

- ➔ An international event showcasing innovations in family farming held in the Southern Common Market (MERCOSUR) in partnership with the Specialized Meeting on Family Farming (REAF), the Cooperative Program for Agrifood and Agroindustrial Technology Development in the Southern Cone (PROCISUR) and Paraguay's Ministry of Agriculture and Livestock (MAG) (200 participants from seven countries).
- ➔ A virtual course on family farming and rural development, with 150 participants from the Southern and Andean regions.
- ➔ The program "Associative Encounters: Agribusiness internships in Family Farming", which led to the creation of a network of 50 organizations offering internship services (126 members in the Southern, Andean, Central and Caribbean regions).
- ➔ Various innovative tools and approaches for knowledge transfer in family farming, through courses and studies on policies, extension, innovation, gender, and knowledge management for family farming.

New rural extension methodologies: IICA implemented several courses, coordinated via horizontal cooperation and with academia and specialized national agencies, which enhanced the skills of 98 extension workers from Chile's National Agricultural Research Institute (INIA) and the Agricultural Development Institute (INDAP).

Access to timely information: Nearly 1500 small and medium-scale producers in the Q'eqchi' territory in Guatemala now receive information on climate, prices, productive technology, and other matters of interest in Spanish and the Q'eqchi' language through the TOTOGEO platform, that operates jointly with the Universidad Rafael Landívar, the Universidad de San Carlos, the Guatemalan Radiophonic Education Federation, the Verapaces Federation of Cooperatives, and the Association of Cardamom Producers, with financial support from the FAS/USDA.

Innovative Central America: The EU-funded Regional Program for Research and Innovation in Agricultural Value Chains (PRIICA) made available to 4000 members of 24 local innovation consortia more than 25 technologies and practices validated by the national agricultural research institutes of six Central American countries. Topics dealt with related to varieties of tomato, cassava, potato, and avocado, integrated pest and soil management, fertilization, and postharvest and marketing processes, including business plans designed to generate income for smallholders.

Specific products

Protected agriculture: Working with the Caribbean Agricultural Research and Development Institute (CARDI) and Guyana's National Research and Extension Institute, IICA set up two greenhouses to serve as demonstration facilities for producers and students for research on agricultural productivity and production costs. The Ministry of Agriculture, Food and Water Management (MAFFW) of Barbados increased its capacity for innovation with protected agriculture systems, with IICA supplying materials and training its staff.

Rice: In the Dominican Republic, producers in the provinces of Monte Plata and Duarte adopted the intensive rice-growing system, after participating in training programs. Research on this system is also under way in Venezuela, Colombia, and Costa Rica.

Bioinputs: Argentina, Colombia, Ecuador, and Nicaragua enhanced their capabilities with respect to the utilization of bioinputs in agriculture, which will favor climate change mitigation and bio-business development.

Biotechnology: IICA contributed and reviewed several proposals on biotechnology and biosafety in Ecuador and Guatemala that were used to make decisions on the utilization of genetic modification technology and its products, which will then have an impact on the reduction of trade barriers, expansion of product supply, and improvement of competitiveness. IICA has also published biotechnology and biosafety bulletins.

Renewable energy: Under the joint project being implemented in Peru by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and IICA, entitled “Fund for Sustainable Access to Thermal Renewable Energies (FASERT),” 8518 families acquired “improved stoves”.

Flowers: IICA promoted the application of agricultural waste for composting and beneficial fungi to control pests and diseases in Paraguay’s flower-growing chain.

Dual purpose agriculture: In Venezuela, IICA worked with the Integrated Dairy Development Program to enhance the skills of 8000 producers through the application of an integrated approach based on good agricultural practices.

Honey: In several of the Institute’s member countries, honey producers began using Perone hives from Argentina, an innovation for beekeepers who produce honey in barrels.

Fish: Under the US-funded Program to Support the Improvement of the Productivity and Competitiveness of the Agricultural Sector (PRESSAC), a system for feeding fish with the aquatic plant Lemna minor was introduced in the municipality of Bayaguana, in the province of Monte Plata in the Dominican Republic. Fourteen demonstration farm modules were set up.

Small ruminants: IICA and the St. Lucia Ruminants Cooperative Society established a forage bank, an innovation that will promote resilience in the value chains of small ruminants.

SUCCESSFUL INNOVATION PROJECTS IMPLEMENTED WITH COOPERATION FROM IICA

In compliance with the mandate of the ministers of agriculture of the Americas, and in accordance with the 2010-2020 Strategic Plan and the 2010-2014 and 2014-2018 Medium-term Plans, IICA has implemented a broad range of projects related to technological and institutional innovation.

Among the most successful cases are:

A. The Network for the Management of Innovation in the Agrifood Sector (INNOVAGRO)

As indicated in its basic document, the Network for the Management of Innovation in the Agrifood Sector (INNOVAGRO) was created on the initiative of the National Coordinator of the Produce Foundation in Mexico (COFUPRO) and IICA, giving rise to (INNOVAGRO 2011):

“Strengthen the innovation management processes in the agrifood sector via an exchange of knowledge, information, technical cooperation, and experiences, through

the creation and operation of the Network for the Management of Innovation in the Agrifood Sector”.

Furthermore, this document states the following:

Mission

“To promote, disseminate and instill a culture of innovation among the strategic players in the agrifood innovation systems through actions relating to cooperation and exchange, services, and information systems”.

Vision

“To be internationally recognized as a network leader through strategic leadership of innovation and innovation management processes for productivity, competitiveness, sustainability, and equity in the agrifood sector”.

Specific objectives

To support the members of the Innovagro Network in strengthening the Agrifood Innovation Systems through actions that facilitate dialogue, exchange and strategic partnerships.

- a. To strengthen the capacities of the members of the Innovagro Network in innovation and innovation management in the agrifood sector.
- b. To support the members of the Innovagro Network in the promotion and implementation of innovations and innovation management processes on behalf of the agrifood sector, through information services and systems.
- c. To provide different technical cooperation mechanisms to the institutions involved in innovation and innovation management.
- d. To disseminate successful cases of innovation and innovation management within the agrifood sector.
- e. To facilitate cooperation and exchange among the institutions, through joint action by the members of the Network with regard to innovation management in order to support a process of continuous improvement and implementation of collaborative actions.

- f. To promote the creation of in-person and virtual forums that facilitate dissemination, dialogue, and analysis of the innovation management process within the agrifood sector.
- g. To promote and support institutional innovations by the different actors participating in the National Agrifood Innovation Systems.
- h. To promote technical cooperation among institutions involved in innovation and innovation management.

Participants

- ➔ Private stakeholders linked to the agrifood chains.
- ➔ Public institutions and the national agrifood innovation institutes, or their equivalent, which have been recognized as the main technology providers and which are responsible for innovation management.
- ➔ Universities and higher education institutions.
- ➔ Ministries and secretariats linked to innovation and innovation management processes.

Among the institutions and countries participating in the Network are:

- ➔ Argentina
- ➔ Bolivia
- ➔ Brazil
- ➔ Chile
- ➔ Colombia
- ➔ Costa Rica
- ➔ El Salvador
- ➔ Spain
- ➔ Guatemala
- ➔ Netherlands
- ➔ Mexico
- ➔ Nicaragua
- ➔ Peru

BOX 2: Institutions Participating in the INNOVAGRO Network in 2011.

No.	INSTITUTION	COUNTRY
1	Inter-American Institute for Cooperation on Agriculture (IICA)	Americas
2	Bishop Colombres Agroindustrial Experimental Station (EEAOC)	Argentina
3	National Agricultural Technology Institute (INTA)	Argentina
4	Ministry of Science, Technology, and Productive Innovation (MINCYT) Secretary of Planning and Policies in Science, Technology and Productive Innovation	Argentina
5	National University of Quilmes	Argentina
6	Promotion and Research of Andean Products (PROINPA)	Bolivia
7	Brazilian Agricultural Research Corporation (EMBRAPA)	Brazil
8	Campinas State University (UNICAMP)	Brazil
9	Fruit Development Foundation (FDF)	Chile
10	Agrarian Innovation Foundation (FIA)	Chile
11	Agricultural Research Institute (INIA)	Chile
12	Pontifical Catholic University of Chile	Chile
13	University of Talca	Chile
14	Presidential Agency for Social Action and International Cooperation	Colombia
15	Administrative Department of Science, Technology, and Innovation (COLCIENCIAS)	Colombia
16	Ministry of Agriculture and Rural Development	Colombia
17	Foundation for the Promotion of Research and Transfer of Agricultural Technology of Costa Rica (FITACORI)	Costa Rica
18	National Institute for Innovation and Transfer of Agricultural Technology (INTA)	Costa Rica
19	University of Costa Rica	Costa Rica
20	CONACYT	El Salvador
21	Roberto Quiñones National School of Agriculture	El Salvador
22	Foundation for Agricultural Technology Innovation (FIAGRO)	El Salvador
23	Ministry of Agriculture and Livestock National Center for Agricultural and Forest Technology (CENTA)	El Salvador

BOX 2: continuation...

No.	INSTITUTION	COUNTRY
24	Ministry of Education (MINED)	El Salvador
25	Catholic University of El Salvador (UNICAES)	El Salvador
26	University of El Salvador (UES)	El Salvador
27	Don Bosco University	El Salvador
28	International School of Excellence in Agriculture	Spain
29	Secretariat of Nutrition and Food Security	Guatemala
30	University of Wageningen	Netherlands
31	National Coordinator for the Produce Foundations (COFUPRO)	Mexico
32	Agriculture Related Trusts (FIRA)	Mexico
33	National Fund for Support to Solidarity Companies (FONAES)	Mexico
34	National Research Institute for Forestry, Agriculture and Livestock (INIFAP)	Mexico
35	National Fisheries Institute (INAPESCA)	Mexico
36	Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA)	Mexico
37	Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA)	Mexico
38	National Technology Research and Transfer System (SNITT)	Mexico
39	Autonomous University of Chapingo (UACH)	Mexico
40	National Autonomous University of Mexico (UNAM) - Social Research Institute	Mexico
41	National Autonomous University of Mexico - Coordination of Innovation and Development	Mexico
42	Nicaraguan Council for Science and Technology	Nicaragua
43	Foundation for Technology, Livestock and Forest Development (FUNIC)	Nicaragua
44	National Board of Science, Technology and Innovation (CONCYTEC)	Peru
45	Dominican Agricultural and Forestry Research Institute (IDIAF)	Dominican Republic

Source: INNOVAGRO 2011 (<http://www.redinnovagro.in>)

Structure

The Network has a Central Unit that functions as a management body and is made up of:

- ➔ A Board of Directors comprising representatives of the national institutions specializing in innovation and management, as well as IICA; they all participate with the right to speak and vote. It meets at least once a year and is made up of member country institutions that designate a president and a vice president who alternate in the position each year. Additionally, the person at IICA Headquarters who is responsible for the Innovation Program also participates.
- ➔ An Executive Committee, made up of representatives of institutions selected by the Board of Directors.

Financing

Financing for the INNOVAGRO Network is derived from voluntary contributions from the Member governments and institutions within the Network, as well as multilateral cooperation organizations and agencies, which are deposited in a fund administered by IICA, the body that functions as the Executive Secretariat of the Network.

Constitution

On 25 May 2011 a workshop was held in Guadalajara, Jalisco, where institutions specializing in innovation management participated and the Constitution of the INNOVAGRO Network, its structure, and the work plan for the first two years were analyzed and approved.

Results

In January 2017, a meeting was held in Mexico City under the theme “Dialogue on innovation in the agrifood sector”, organized by IICA and the INNOVAGRO Network. At the meeting, the Director-General of IICA, Víctor M. Villalobos pointed out that the four challenges facing the agrifood sector throughout the hemisphere with respect to its development were improvements to its productivity, competitiveness, food hygiene and innovation.

At this meeting, it was recognized that, in the six years the INNOVAGRO Network has been in existence, development of innovations, knowledge transfer and training in the different countries that make up the network have been promoted. Furthermore, it was reported that the network in 2017 had the support of 82 institutions in 16 countries (Mexico, Argentina, El Salvador, Nicaragua, Colombia, Costa Rica, Uruguay, Chile, the Netherlands, Brazil, Guatemala, the Dominican Republic, Bolivia, Spain, Peru and Israel), and that it has trained 3500 extension workers and producers in 8 countries, both face-to-face and virtually.

B. Family agriculture plan (PAF) in El Salvador

Below is a transcription of a portion of the address given by the Director-General of IICA, Víctor M. Villalobos, during his presentation in 2013 of the document “Family Agriculture Program for the Production Chain (PAF CP): family agriculture plan of El Salvador”, (Miranda 2013:9-16):

During the second half of 2010, the Ministry of Agriculture and Livestock (MAG) made one of the greatest bets ever on behalf of the agricultural sector of El Salvador over the last decades: the Presidential Family Agriculture Plan, PAF. Its purpose was to carry out a differentiated, comprehensive and fast-track intervention plan that would restore dignity to hundreds of thousands of families that were living the socioeconomic realities of poverty.

This intervention premised that the producers could escape their isolation and marginalization, if they were given access to technological innovation, to entrepreneurship, to formal markets, and to knowledge management networks and structures.

In its component entitled Productive Chains, the PAF defined actions for increasing the availability of food. Through a process of modernization and use of best practices, the goal was to significantly increase the levels of productivity and agricultural profitability, and, at the same time, facilitate a process of articulation and capacity development in the areas of marketing and business management. In the end, the development of competitive capabilities would be achieved, which would make

it possible to obtain higher incomes through greater and better insertion into the local markets.

[...]

In order to take advantage of its experience in the Western Hemisphere, the Ministry of Agriculture and Livestock (MAG) entrusted the Inter-American Institute for Cooperation on Agriculture (IICA) with the technical co-execution of the Production Chains Program (PAF CP) during the first two years of its implementation. This meant that the Institute would assume responsibility for eight agro-production chains: basic beans, honey, dairy products, aquiculture, vegetables, fruits, cacao, and coffee.

With IICA, the Program began in July 2011. The first year, some 15 918 families were involved: 5700 in basic beans, 2014 in dairy products, 2900 in fruits, 2900 in coffee, 1000 in beekeeping, 449 in vegetables, 285 in cacao, and 670 in aquiculture. During the first two years, with the collaboration of various sectors of the Government, optimal conditions were created for full execution of the program.

In order to solve problems as quickly as possible and take advantage of existing opportunities, it was necessary to obtain results expeditiously: construct productive economies of scale through competitiveness and associativity; have an impact on the chains in order to supply the formal domestic markets; transfer knowledge and good agricultural practices with regard to postharvest and value-added; use a combination of methodologies and simple teaching strategies in order to transfer knowledge to the farmers; and promote the appropriation of this knowledge, as well as empowerment, by encouraging active participation of both men and women.

The first results were obtained rapidly, but it was obvious that this only was the beginning, and that this was a process that would take several years. Increases in productivity have already been achieved, ranging from 13 % to 80 %, depending on the product; production costs have been reduced, either through more rational use of inputs, or through a reduction in prices associated with the purchase of inputs in most of the chains. Improvements are also observed in meeting the standards of formal markets, with type “A” qualities in products such as honey, dairy products, fruits and vegetables, and coffee, among other products.

Furthermore, synergies have been achieved in the mobilization of material and financial resources, ranging from 5 dollars per dollar invested (for example, in honey), up to 15 dollars per dollar invested (for example, in aquiculture). Additional paid jobs have been created for each family, up to 3 permanent jobs per hectare (for example, in vegetables).

Better use of resources has been linked to favorable agricultural practices with respect to land, water and forestry.

Yields have been obtained that make it possible to multiply the net income per hectare in the areas participating in the Program. In one hectare of banana, up to 8000 dollars in profit can be generated and in cacao, up to 2000 dollars per hectare. In honey, an increase of 1400 dollars has been achieved per apiary of 50 beehives; in aquiculture, 1600 additional dollars per hectare per year; and in dairy products, 1100 dollars per year on an average farm with 10 dairy cows.

The empowerment shown by both male and female producers is remarkable, since it is based on a model of innovation that has its roots in area-based social networks and in multiple articulations among the stakeholders within the chains, making it possible to multiply the flow of knowledge. The farmers frequently point out that what has been learned and “already” grasped, can “never be taken away from them”; the seed has been planted, the harvests they are being reaped.

In terms of institutional strengthening, the situation is also positive. The process of transfer of full responsibilities from the Institute to the official bodies was started from the beginning of the Program, as a deliberate and planned strategy.

[...]

Principal results of the PAF in El Salvador

Application of this model, which benefited 16 000 producers, produced the following results (Miranda 2013):

- ➔ Creation of eight technical forums in different agricultural production chains. These forums became opportunities for dialogue that resulted in twelve studies

of establishing the characteristics of the chains. The foundations of a public policy to support competitiveness were laid, and four cross-cutting programs for public policy (marketing, credit, cooperative activity and infrastructure) were designed.

- ➔ Construction of 28 collection centers and services, which are basic mechanisms for generating associativity.
- ➔ Training of 608 producers in agribusiness management through the methodology “Entrepreneurial training for economic competency.”
- ➔ Design of new business models translated into 21 productive coordination plans, market linkages and product innovation. These plans were the result of over 366 work sessions at the local level.
- ➔ Formulation of 24 investment projects that facilitated the training of 1289 agro-entrepreneurs, as well as leveraging of 1.5 million dollars in non-reimbursable resources to capitalize associative companies.
- ➔ Creation of 588 production development centers, through which various technological innovations were promoted. The producers who used them increased their production performance by at least 15 % and their income by 10 %.
- ➔ Expansion of the institutional capabilities of the Ministry of Agriculture and Livestock of El Salvador and the National Center for Agricultural and Forestry Technology (CENTA) in order to provide technical assistance to small- and medium-scale producers, who were trained through tours, sharing of experiences and other activities.
- ➔ Implementation of an online follow-up and monitoring system within the framework of the PAF-Production Chains. Thus, the national authorities and 300 technical personnel and extension workers were able to obtain real-time information generated in the field.

C. Agricultural Innovation Network Project (SICTA Network). Corn and bean production chains

The Agricultural Innovation Network Project (SICTA Network), carried out by IICA in Central America with financial support from the Swiss Agency for Development and Cooperation (COSUDE), benefited 101 207 producers (30 % women and 70 % men). Of this number, 81 671 were taught innovative technologies and 19 536 adopted them (techniques relating to pre-drying, improved varieties, machinery, microorganisms, and inoculants, among others). 52 % of the users of said technologies managed to increase their earnings by more than 15 % and food availability by 18 %, when compared to the years prior to the execution of the project.

In Nicaragua, the improvement in income experienced by corn and bean producers following the adoption of new technologies is one of the most significant results of the project.

In general, the new technologies helped to reduce losses and costs, to improve productivity, quality and market positioning, and to increase value added (IICA n. d. b).

Innovation networks

5 national networks and 21 area-based networks for knowledge management were consolidated in the corn and bean chains. 215 partnerships were also promoted to identify problems, find solutions, and execute projects.

The networks are comprised of 318 organizations, among them farmers' organizations, the private sector, government institutions, nongovernmental organizations, international cooperation agencies, and representatives of academia.

Demands were met based on seeding time, and more than seven learning mechanisms were implemented, 55 technological innovations were promoted, and more than 300 000 technical guides and 7 tutorial videos were distributed.

Proyectos

In partnership with several entities, 30 projects that were co-financed by IICA were executed in 7 countries of Central America, for more than 2.6 million dollars.

These projects responded to the needs of the corn and bean producers in the different stages of the chain. 41 % of them responded to primary production needs, 31 % met postharvest needs and 28 % responded to needs in the areas of marketing and processing.

The technologies that had the most effect on income were:

1. *Ecofogón* in Nicaragua
2. Reduction of planting density in Nicaragua
3. Drying stand in Nicaragua
4. Bean varieties in Honduras
5. Plastic cover protection in Nicaragua
6. Collection and service center in El Salvador
7. Collective corn shelling service in Nicaragua
8. Inoculation of beans in Nicaragua
9. Corn varieties in Guatemala
10. *Ecofogón* in Honduras
11. Good agricultural practices in Costa Rica
12. Corn varieties in Honduras
13. Collective marketing practices in Nicaragua
14. Collective marketing in Costa Rica

The seven technologies that were most frequently adopted were the following:

1. Collective corn shelling service
2. Improved varieties of beans
3. *Ecofogón* in Honduras
4. Planting density in Nicaragua
5. Use of inoculants in beans in Nicaragua
6. Corn varieties in Guatemala
7. Predrying beans with plastic in Nicaragua and El Salvador

Principal tangible products:

- » Establishment of knowledge management networks: 5 national networks and 21 area-based networks. These integrate various public and private stakeholders.
- » Preparation of a methodology for working in a knowledge management network: simple guidelines for creating networks were published.
- » Supporting material for the dissemination of innovative technologies: 13 technical guides on technological innovations for the corn and bean chains, 11 fact sheets, 7 tutorial videos for learning how to use innovative technologies, flipcharts and guides for identifying diseases and pests in beans. This material was in great demand and was well accepted by the users (more than 300 000 thousand guides have been distributed throughout Central America).
- » Identification and dissemination of 55 technologies for the corn and bean chains.
- » Creation of an electronic platform: the SICTA Network observatory. The platform provided the public with information on the technologies that have been disseminated throughout the knowledge management networks; with a technological inventory of corn and beans with 520 technologies identified; a directory of the members of the networks and of persons doing research on these crops; and studies carried out by the project and associated institutions. Additionally, five virtual forums have been held on the *mancha de asfalto* fungus, climate change, and sharing of experiences in collective marketing in Central America. The site had more than 900 000 hits in 2014.
- » Consolidation and development of the Technical Group on Technologies, Research and Extension for Agricultural Innovation of the Central American Agricultural Council.
- » In Nicaragua, under the leadership of the Nicaraguan Institute of Agricultural Technology (INTA), the foundation was laid for the establishment of a research and agricultural innovation system, within which area-based innovation groups are being formed.

The project saw participation from ministers of agriculture in Central America, entrepreneurs, academic bodies and international research centers, such as the International Maize and Wheat Improvement Center (CIMMYT) and the International Center for Tropical Agriculture (CIAT), as well as institutions specializing in agricultural research throughout the region: the INTA in Nicaragua, the Directorate of Agricultural Science and Technology (DICTA) in Honduras, the Institute of Agricultural Science and Technology (ICTA) in Guatemala, the Agricultural Research Institute (IDIAP) in Panama, the National Institute for Innovation and Agricultural Technology Transfer (INTA) in Costa Rica and the National Center for Agricultural and Forestry Technology (CENTA) in El Salvador.

D. Regional Program for Research and Innovation in Agricultural Value Chains (PRIICA)

The Regional Program for Research and Innovation in Agricultural Value Chains (PRIICA) is an initiative promoted by the European Union and IICA. Its objective is to help to increase the availability of food and access to it, and generate international public goods through agricultural research on the production chains for potato, cassava, tomato and avocado in Central America and Panama.

The main challenges it faces are the following:

- a. To improve the living conditions of the beneficiaries, through the generation of income and consumption of products from the chains.
- b. To consolidate agricultural research based on the needs of the beneficiaries.
- c. To strengthen extension and transfer services in order to further promote the adoption of technology, knowledge and practices.
- d. To diversify the national innovation systems through the articulation of public-private partnerships.

All its activities are carried out by IICA, jointly with the national agricultural research institutes (INIA) and other stakeholders within the public and private sectors in the participating countries.

PRIICA is a program with funding amounting to 5.6 million Euros from the European Union, as well as contributions from IICA.

PRIICA bases its work strategy on the creation of local consortia for agricultural technology research and innovation (CLIITA), and on the consolidation of four regional networks, one for each product-chain: potato, cassava, tomato and avocado.

Through IICA coordination, and in collaboration with the INIA, a process of research is conducted which focuses on the following topics:

- ➔ Selection and validation of plants with superior agricultural characteristics.
- ➔ Management of pests and diseases and biological control methods.
- ➔ Improvement of management practices with respect to products from the chain (pruning, grafting and fertilization, among others).
- ➔ Efficient seed production and storage systems.
- ➔ Processing and value added processes.

The Program bases its work on five strategic approaches designed to strengthen the actions to be developed and the results to be generated. They are:

- i. Innovation systems approach.
- ii. Value chain focus.
- iii. Diversification approach.
- iv. Small producers focus.
- v. Focus on climate change mitigation and adaptation.

These approaches include the development of activities based on a research and innovation project with emphasis on the four value chains identified, which are important products for consumption and the dietary and nutritional needs of the region, and which have the potential to generate income for small producers through the sale of surplus goods on the local markets. This seeks to reduce the vulnerability of the target groups and to advance nutrition and food security.

During its period of intervention the Program aims to achieve three results:

1. 24 consortia created in rural communities for generation and validation of new technologies, and the application of good practices and knowledge.

2. Technologies and innovations disseminated through knowledge management processes, in order to strengthen the competences of the beneficiaries.
3. Strategic plan designed for the region, which integrates the learning and experiences of the participants, and guides their research and innovation activities

Following the research phase, and through the implementation of strategic innovation plans (SIP), the Program promotes the adoption of technology, strengthening of strategic partnerships and exchange of knowledge with a view to achieving sustainability of the medium- and long-term actions of its members.

PRIICA works at three levels or areas of intervention (PRIICA 2017):

1. **Regional:** Six countries participate: Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama. Four regional networks with 30 researchers and teaching experts have been strengthened among the national agricultural research institutes (INIA) in Central America and Panama.
2. **National:** Researchers from the National Institute for Innovation and Transfer of Agricultural Technology (INTA), the National Center for Agricultural and Forestry Technology (CENTA) El Salvador, the Institute of Agricultural Science and Technology (ICTA) of Guatemala, the Directorate of Agricultural Science and Technology (DICTA) of the Secretariat for Agriculture and Livestock (SAG) in Honduras, the National Institute for Innovation and Agricultural Technology Transfer (INTA) of Nicaragua, and the Institute of Agricultural Research (IDIAP) of Panama.
3. **Local:** They work with 24 local consortia for research and agricultural technology innovation (CLIITA) made up of public-private stakeholders from rural communities.

E. FONTAGRO

The Regional Fund of Agricultural Technology (FONTAGRO) is a unique cooperation mechanism for agricultural innovation in LAC and operates through regional platforms. It comprises 15 countries that have contributed towards a capital that exceeds 100 million dollars, and is sponsored by the Inter-American Development Bank and IICA (FONTAGRO 2017a).

Its vision is to be an internationally recognized cooperation mechanism for sustainable strengthening of agricultural and agro-industrial innovation among the member countries.

Its mission is to contribute to innovation in family farming through cooperation among the member countries, by promoting competitiveness and food security in an equitable and sustainable manner.

It therefore tries to contribute to increasing competitiveness in the agricultural sector, poverty reduction, and sustainable management of natural resources in the region. FONTAGRO also functions as a discussion forum on agricultural and rural innovation in the region.

The Medium-term Plan of FONTAGRO revolves around the improvement of family agriculture, for which it focuses on four topics:

1. Technological, organizational, and institutional innovation;
2. Climate change adaptation and mitigation;
3. Sustainable intensification of agriculture and management of natural resources;
4. Value chains and competitive territories.

The member countries of FONTAGRO are:

- » Argentina
- » Bolivia
- » Chile
- » Colombia
- » Costa Rica
- » Ecuador
- » Spain
- » Honduras
- » Nicaragua
- » Panama
- » Paraguay
- » Peru

- » Dominican Republic
- » Uruguay
- » Venezuela

The direct beneficiaries of FONTAGRO activities are:

- ➔ National agricultural innovation and research institutions.
- ➔ Regional institutions and international organizations.
- ➔ Companies, producer associations, cooperatives.
- ➔ Researchers, leaders of member institutions, co-executing, associated and collaborating institutions for the projects financed by FONTAGRO.
- ➔ Extension workers, professionals, and technical personnel in the agriculture sector.
- ➔ Government representatives responsible for public investment in agriculture, including those in the agricultural policy sector.
- ➔ Current and potential beneficiaries of the projects financed by FONTAGRO throughout the region.

Indirect beneficiaries of FONTAGRO activities:

- ➔ Consumers, students, suppliers, neighboring communities, among others.

Results

The number of approved projects was 108; the amount approved, 87.8 million dollars; contribution from other investors - 15.6 million dollars; beneficiary countries, 25; technologies generated - 35; new technologies for Latin America and the Caribbean - 15, while the technologies of world importance were 4; 69 % of its results were used by end users, while 77 % of its results were incorporated into national systems. Among the products dealt with by FONTAGRO were: tomato, potato, banana, rice, fruit trees, livestock, corn, beans, chili, cassava, beekeeping, wheat, coffee, grasses, and bioinputs (FONTAGRO 2017b).

F. Production of pine nut oil for electrical energy generation in the Galapagos Islands

The Galapagos Islands were declared a natural Heritage of Mankind in 1979 and six years later (1985), as a Biosphere Reserve by UNESCO. In 2007, UNESCO declared

the archipelago a Heritage of Mankind at Environmental Risk, and it was even, until 2010, on the List of Heritage of Mankind at Risk. The principal source of income of the archipelago is tourism (it welcomes 200 000 tourists each year). The islands have been a national park of Ecuador since 1959. Diesel is still primarily used to generate electrical power, and this is transported by sea to the island. The environment of the islands has been affected on many occasions by spills of this fuel.

Since 2008 the Ministry of Electricity and Renewable Energy of Ecuador (MEER) has been promoting the production of pure pine nut oil (EVPO), as a substitute for diesel in electricity generation. The pine nut (*Jatropha curcas*) is an endemic shrub that is found in most tropical and subtropical countries.

During the initial experimental stage, the MEER collaborated with IICA and other institutions to implement a pilot plan, the objective of which was to replace diesel oil with pure vegetable pine nut oil for electricity generation on the Floreana Island in the Galapagos, through the agro-industrial development of live pine nut fences located in the province of Manabí (IICA n.d.a).

The MEER entrusted IICA with the agricultural and industrial EVPO process. At the end of that experimental phase, IICA was asked to gradually transfer the technical and commercial capabilities to the collectors/producers who were organized in cooperatives.

The idea behind the project was to help to reduce the consumption of diesel for electricity generation in the Galapagos Islands, and at the same time improve the economic performance of the chain of suppliers (small producers/collectors) of raw material for the biofuel production. The Multilateral Investment Fund (FOMIN) also ensured that the cooperatives of producers and pine nut collectors in the province of Manabí increased their productivity and operated formally in the biofuel value chain in Ecuador.

Pine nut collection is in the hands of small farmers/low-income collectors in the driest and most depressed areas of the Ecuadorian coastal zone of Manabí, where there is a base of approximately 7000 kilometers of live pine nut fences. These

communities were affected by a strong earthquake and it was hoped to revitalize them by generating work and income from this operation.

This initiative complements other renewable energy projects that are carried out in the archipelago. It is expected to comprehensively reduce the use of fossil fuels. The amount of EVPO fuel that is being produced today is not enough to satisfy the demand for diesel of the Galápagos Provincial Electric Company, Inc. (ELECGALÁPAGOS Inc.).

Description of the project: The project falls under the initiative “Zero Fossil Fuels for Galápagos”, which seeks to replace the diesel that is used to generate electrical power on the Floreana island with pure vegetable oil from the live pine nut fences that are on the Ecuadorian coast. The target population of the project are the inhabitants of the Floreana island – it is expected that they will receive electrical power from a renewable source 24 hours a day -, as well as the pine nut farmers in the provinces of Manabí and Santa Elena - it is expected that, in addition to training, they will receive an additional income and that will help to improve their living conditions. Sustainability of this project falls within the model of popular and collective economy.

Product/Service: Hybrid system for electricity generation (thermal-photovoltaic) on the Floreana island. Pine nut oil production chain.

Conclusions: Two electricity generators adapted for the use of pine nut vegetable oil as fuel were installed on the Floreana island; the machine house was adapted, the fuel storage system of the generation plant on Floreana was replaced, and the pine nut oil was guaranteed from 2009 to 2015. With respect to agriculture, high performance varieties of pine nut were identified, pine nut reproduction systems were designed, and 38 localities in the provinces of Manabí and Santa Elena participated as suppliers of pine nut and benefited from the project in the form of training, plant reception for reproduction and additional income at a time when other agricultural activities are becoming scarce, among other benefits. The pine nut extractor plant was also put into operation in Portoviejo.

Strategic partners were sought for the implementation of the project, such as the GIZ, which provided funds from the German Federal Ministry for Environment,

Nature Conservation, Building and Nuclear Safety, within the framework of the World Climate Protection Initiative. Work was conducted with the INIAP Portoviejo Experimental Station and IICA for research and implementation of the agricultural component (MEER 2016).

G. Program: “Sustainable Forest Management in the Andean Region”

The purpose of the Program “Sustainable Forest Management in the Andean Region (MFS)” is to ensure a greater contribution of forest resources to the sustainable development of the Andean region. Its purpose is to test and introduce innovations aimed at eliminating the “bottlenecks” that impede the development of the forestry sector in Bolivia, Colombia, Ecuador, and Peru. To this end, between 2011 and 2015, through an agreement signed between the Ministry of Foreign Affairs of Finland (MAEF) and IICA, the MFS Program implemented, together with partners within the public and private sectors and civil society, a portfolio of 24 pilot projects and feasibility studies in four areas: i) reward mechanisms for environmental services aimed at climate change mitigation; ii) reward mechanisms for environmental services in water and restoration; iii) value added from sustainable forest products; iv) community forest management and sustainable management. The 24 initiatives developed by the MFS Program concluded at the end of 2014; in 2015 the transfer of results phase started to promote sustainability, scaling-up, and replication of the promising innovations in the Andean countries.

1. “MFS Colombia”

Name of the innovation: “Reward mechanisms for water and climate change mitigation services in river basins.” It seeks to contribute to the sustainability and delivery of environmental services in the Guarínó river basin in Colombia. Participating entities: Caldas Regional Autonomous Corporation (Corpocaldas), Institute of Environmental Studies of the National University of Colombia.

Beginning: 5 September 2012; close: 9 December 2013.

Financing: MFS: USD 186 642; counterpart: USD 29 934; total: USD 216 576.

Description of the innovation

This proposal consisted of designing and launching a “Program for compensation for environmental services in the Guarínó river basin (PCSAG)”, which included a mechanism for compensating communities and interested persons for conservation and promoting actions for the recovery of strategic areas of the basin. The goal was to capitalize on a process of governance in the watershed area that started in 2004. The objectives of this proposal were to maintain and improve the quality of the water, reduce the impact of floods and the sedimentation of rivers, improve the connectivity between patches of forest, and conserve the biodiversity, the soil, and the beauty of the landscape.

Importance

The Guarínó river basin extends for approximately 84 000 hectares. Between 1990 and 2010, the rate of deforestation was 208 ha/year as a result of the expansion of the agricultural and livestock area. Use of the forest to improve dwellings and make firewood contributes to further increasing the threat facing the Andean forest, a critical ecosystem for water management and biodiversity conservation in the region. If this pace of deforestation continues, in 10 years the deforested area will be up to 2000 hectares. Additionally, there is a strong process of degradation of forests and forest coverage due to agricultural activities. From the point of view of quality of life, several indicators point to the difficult socioeconomic status of the communities bordering the basin. In the department of Caldas, 30 % of the population cannot meet their basic needs, a situation that has worsened with the coffee crisis (which has caused the local currency to be revalued, making production costs and coffee harvesting more expensive) and climate change which has intensified the problems of pests and diseases in agricultural crops to the detriment of its performance and therefore, the income of the farmers.

It is estimated that the watershed supplies a population of 112 445 from 9 municipalities, and that the demand amounts to some 180 liters of water per person per day. This basin houses the Guarínó–Isagén transfer, which has been in operation since 2010. This facility captures the water from the Guarínó river, which means that

it is essential to maintain its flow. One of the most serious problems has been the deterioration in the quality of the water and the decrease in its quantity. If the current trend of deforestation continues, in 10 years the water deficit will be 9240 million liters. From the point of view of quality, the principal water pollution sources are dumping of domestic wastewater, slaughterhouses, agricultural activities, livestock activities, mining, and some food industries in the municipality of La Dorada. Furthermore, sediment production in the Guarínó basin is estimated at 464 t/km²/year, with the primary causes being agricultural activities and deforestation.

With the Task Force of the Immediate Action Plan for the Guarínó River Basin (EPI) as the coordinating entity, the environmental services payment mechanism was implemented in order to contribute, not only to the preservation of ecosystems and the environmental services that they provide, but also to improving the quality of life of those who live on the properties where conservation activities are carried out. The initiative emerged in 2012, spearheaded by the Aldea Global Corporation, in which local stakeholders within the basin and environmental authorities of the region participated, such as the Caldas Regional Autonomous Corporation (Corpocaldas) and the Tolima Regional Autonomous Corporation (Cortolima), ISAGEN Inc. (a mixed public utility company, linked to the Ministry of Mining and Energy), the municipalities of Marulanda and Manzanares in the department of Caldas, as well as environmental authorities in the dependencies, and the *Programa de Paz del Magdalena Centro* (Peace Program of the Magdalena Center) (a locally led organization based on its experience in development projects, environmental conflict resolution and planning).

Results

After five years of operation, the program had managed to preserve or restore 2672 hectares and generate 3208 million additional liters of water within the basin. The direct beneficiaries were 200 people.

2. “MFS Ecuador”

Name of the innovation: “Incentives for the restoration of forests through connectivity and adaptation of the natural and human systems, and the delivery of

ecosystem services within the ecological corridor Llanganates - Sangay, Ecuador” (IICA, MFS and MAEF 2015).

Beginning: 1 May 2013; close: 30 November 2014

Financing: MFS: USD 254 077.00; counterpart: USD 40 897; Total: USD 294 974.

Description of the innovation

This project sought to improve the restoration and connectivity processes among the forest ecosystems of the Llanganates - Sangay Ecological Corridor (CELS) and the surrounding areas. The comprehensive long-term restoration plan of the CELS took into account the combination of good restoration practices, agro-forestry systems, and conservation of forest areas. In collaboration with the decentralized autonomous governments (DAG), the goal was to define the bases of the project, select the relevant technical and regulatory aspects, and determine the capacities that producers and decision-makers needed in order to be linked directly to the proposal and establish public policies geared toward restoration of degraded areas, while taking the landscape into consideration. This initiative was part of the validation and implementation of the Partner Forest Program (PSB) of the Ministry of the Environment of Ecuador.

Importance

Many ecosystems in Ecuador, including in the CELS area, are experiencing processes of degradation due to inappropriate use of natural resources, which is a situation that affects not only the biodiversity but also the livelihoods of the inhabitants. Within the area, there is a tendency to overuse agricultural chemicals, to prioritize monoculture and to use soils that are unsuitable for both agriculture and livestock. The limited productivity and profitability of the crops is causing the agricultural border to expand, which leads to further destruction of the plant cover, more reduction in water resources and more poverty among those who depend on the natural resources. A vicious cycle is therefore created between poverty and the loss of goods and services from the forest ecosystems.

The restoration and recovery of degraded areas in the CELS is an attempt to integrate and merge best production practices and use of natural resources, while

at the same time recovering and/or contributing to connectivity and restoration of the degraded ecosystems. In the middle of 2013, the PSB initiated a pilot phase of incentives for restoration: USD 21 per/ha/year for three years; however, this amount was not attractive to the farmers. In March 2014, the National Forest Restoration Plan was published, and in it the incentive was adjusted to USD 815 per hectare for 3 years. The opportunity arose therefore to validate, disseminate and implement, at the local level, the incentive for passive restoration, which could be combined with productive actions in agro-forestry systems.

The goal of the innovation in the medium and long-term was to improve connectivity in the CELS, promote forest conservation, restoration of degraded areas, and strengthening of productive systems. Three strategies were implemented for this purpose: i) participation of property owners in the conservation/restoration component of the PBS; ii) passive restoration and recovery of degraded areas through good forest management practices in agro-forestry systems (AFA); iii) training of local governments in topics and activities related to ecosystem recovery and protection.

Results

At the technical level: 18 families within the area benefited from the incentives of the PBS; in total they received USD 92 219/year for saving 13 971 hectares: 744 hectares under conservation (16 farmers), 40 hectares in restoration and a collective property in the Kichwa Canelos Ancestral Community (13 187 hectares) under conservation. This community falls outside of the CELS area.

The agro-forestry systems in degraded areas attracted a group of 100 producers, who received several species of plants for restoration. Therefore, multipurpose plantations were established over 26 hectares (active restoration) in the parishes of Río Negro, Cumandá, Agua Santa, Ulba and Mera. The restored areas represent 6 % of total properties.

At the social/organizational level: the capacities of 108 people (60 women and 48 men) from 103 families were strengthened. The topics covered were: property

management, preparation and application of fertilizers and organic repellents, establishment and management of agro-forestry systems and group nurseries.

At the environmental/climate sustainability level: three of the areas under conservation included in the program were remainders of primary forest and contribute to the protection of the Puyo and Pambay watersheds.

3. "MFS Perú"

Name of the innovation: "Forest plantation technologies for commercial purposes that make it possible to improve species productivity, thus ensuring employment and recovering degraded areas of the Peruvian Amazon region" (IICA, MFS and MAEF 2015).

Beginning: 10 September 2012; close: 15 December 2014.

Financing: MFS: USD 240 250; counterpart: USD 352 538; total: USD 592 788.

Description of the innovation

The project consisted in developing technology packages for the management of forest plantations in degraded areas of the Peruvian Amazon region, department of Ucayali. This project sought to deal with the "bottleneck" that the lack of technology represents for forest plantations in degraded lands. The process started with a test of the forest management practices for five species of commercial value: balsa tree (*Ochroma pyramidale*), bolaina (*Guazuma crinita*), arapari (*Macrobium acaciaefolium*), capirona (*Calycophyllum spruceanum*) and teak (*Tectona grandis*). The innovation also sought to contribute to human resource training at the university level and to disseminate knowledge among the local inhabitants on the management of forest plantations.

Importance

Over the past 50 years, some 9 million hectares have been deforested in the Peruvian Amazon region. According to the Ministry of Environment of Peru, between 2009 and 2011, the deforestation in the Amazon region was at the rate of 105 975 hectares/year, as a result of mining and road infrastructure development projects. With a rate of deforestation of 16 342 hectares/year during the period 2009-2011,

the Ucayali region is one of the main points of deforestation within the country. These areas are in the process of being downgraded by the loss of soil quality caused by poor management, constant fires, grazing and other anthropic disturbances.

Within this context, the Peruvian company Reforesta Perú S.A.C., in partnership with the Backus-Cervecería Foundation San Juan S.A. and the National University of Ucayali, took on the challenge of designing and testing a technology package to recover degraded lands through the establishment of forest plantations with different species that could be used for commercial and/or industrial purposes.

Results

- **At the technical level:** A nursery was constructed with the capacity to produce high-quality genetic and physiological grafts, where modules of micro-tunnels and sub-irrigation chambers were established. The productive capacity of the nursery is 80 000 grafts per production activity, with replications three times a year.
- **At the social level:** Training was given to professionals and university students, local entrepreneurs, cacao producers and the persons in general from seven districts within the region of Ucayali (Callería, Manantay, Yarinacocha, Campo Verde and Nueva Requena in the Colonel Portillo province and Curimaná and Irazola, Padre Abad province). 32 % were women. The goal of this activity was to raise awareness as to the importance of forest plantations.
- **At the environmental level:** the 40 hectares of forest plantations have favored the presence and permanence of the local biota. This aspect is quite remarkable especially when compared with the agricultural use or degradation that is observed in similar areas of the region. An assessment of the fauna around the plantations (by means of a thesis) pointed to the presence of nine species of birds, six species of mammals and five species of reptiles.

H. Central American Fruit-growing Project (PROMEFRUT)

The objective of this program is to prepare and adopt a framework of regional cooperation to promote the competitiveness of fruit-growing in Central America, so that the government sector may become a strategic partner of fruit producers.

PROMEFRUT is the result of the “Central American Innovation Project for the Development of Fruit Agribusinesses” proposal, approved by the Heads of State and Government of the region within the framework of the Seventh Summit of the Mechanism for Dialogue and Consensus-building of Tuxtla, held in 2005.

PROMEFRUT develops two major components:

1. Regional Policy for the Development of Fruit Cultivation (POR-FRUIT) and the corresponding strategic plan.

This component supports the preparation of a regional sub-sectoral policy for the development of fruit-growing (POR-FRUTAS) and a strategic plan (SP) to support the implementation of this policy. POR-FRUTAS is part of the Central American Agricultural Policy (CAAP) and it defines the focus for coordination and regional cooperation, with emphasis on issues and products that have a high impact on the competitiveness of the sub-sector, and where collective regional action can bring additional benefits to fruit growing in the participating countries. The design of the policy was supported by a broad process of consultation with the public and private sectors of the countries involved.

2. Coordination instruments (regional platforms).

Three tools for regional information and coordination support the implementation of the fruit policy in a cross-cutting way:

A. Market Intelligence Platform

A strategic tool that enables policy makers and agri-businesses to:

- ➔ Make strategic decisions about fruit production and the public programs that support it;
- ➔ Analyze local, regional and international markets, as well as the institutions in which they operate; and
- ➔ Get information on specific issues and products.

B. A regional platform for the generation and exchange of knowledge

This is a reservoir of technical information, research and good practices for the competitiveness of fruit growing in Central America, with emphasis on public interventions in support of the subsector. This forum also seeks to:

- ➔ Encourage collaboration between experts in fruit growing;
- ➔ Promote the development of human capital specialized in fruit growing in the region.

C. A regional platform for the promotion of health, quality, and safety

An instrument through which the public sectors (ministries of agriculture and health authorities, among others) and private (associations of producers, laboratories, certification bodies, advisory companies, among others) coordinate regional actions for health, safety and quality throughout the fruit chain.

Investment: USD1 234 000.

Sources of Funding: Inter-American Development Bank (IDB)

Management Committees:

- » Belize: Fruit Program - Ministry of Agriculture & Fisheries.
- » Costa Rica: Non Traditional Fruit Program - Ministry of Agriculture (MAG).
- » El Salvador: FRUTALES - National Center for Agricultural Technology (CENTA)/ Ministry of Agriculture and Livestock (MAG).
- » Guatemala: DEFRUTA-Ministry of Agriculture, Livestock and Food (MAGA).
- » Honduras: National Agri-Food Development Program (PRONAGRO)- Agriculture Secretariat (SAG).
- » Nicaragua: General Directorate of Agricultural Protection and Health (DGSPA)- Ministry of Agriculture and Forestry (MAG-FOR).
- » Panama: National Coordination of Agriculture-Ministry of Development (MIDA).
- » The Dominican Republic: Department of Fruit Development (DEFRUT)-Ministry of Agriculture.
- » Technical assistance: Inter-American Institute for Cooperation on Agriculture (IICA).
- » Technical support: Secretariat of the Central American Agricultural Council (SECAC), International Regional Organization for Plant Protection and Animal Health (OIRSA), and Market Information Organization of the Americas (MIOA).

Achievements and results of the project:

The Executive Directorate of the Mesoamerican Project, as the executing agency, finalized the development of the Mesoamerican Fruit Growing Project (PROMEFRUT)

on June 12, 2012 and immediately proceeded to the final evaluation stage. On May 23, 2012, in Antigua, Guatemala, the Steering Committee, and the Executive Director of PROMEFRUT presented the results and achievements attained during the execution of the project, to several officials and key stakeholders related to the production and marketing of fruits in the Mesoamerican region. The event was held within the framework of the Workshop on Presentation of Results of PROMEFRUT and was attended by representatives of fruit chains in the region, academic entities (Earth University, El Zamorano Pan-American Agricultural School), partners, regional projects and agencies, country officials, presidential commissioners of the Mesoamerican Project and partners in PROMEFRUT: IICA, Executive Secretariat for the Central American Agricultural Council (SECAC), International Regional Organization for Plant Protection and Animal Health (OIRSA), Market Information Organization of the Americas (MIOA), *Mesoamerican Food Security Early Warning System* (MFEWS) and CATIE (Proyecto Mesoamérica 2017).

I.- Program: Partnership in Energy and the Environment with the Andean Region

The projects that were carried out as a part of the Program Partnership in Energy and the Environment with the Andean Region (IICA *et al.* 2012) are mentioned below.

1. Optimization of the combustion process in sugar loaf burners through the implementation of a bagasse dosing system and residual heat recovery.

In the province of Gualivá located in Cundinamarca, Colombia, there is an area of mountains and another area of well-defined flat lands, with 45 000 hectares dedicated to the production of brown sugar cane. The sugar loaf subsector, located in the municipalities of Nimaima, Peña, and Utica, represents 80 % of the economic activity and is the principal source of rural employment; nevertheless, the agribusiness presents serious technological and environmental problems.

The Federation of Brown Sugar Loaf Producers (FEDEPANELA), through a participatory process of technological management that involves the characterization

of processing plants, as well as the design, implementation, adjustment, evaluation, and transfer of technology, will demonstrate to the beneficiary population the potential of the new energy technologies to solve the environmental and socioeconomic problems that are derived from the old technologies of combustion and heat transfer (this is the technology used in the rural areas for processing sugar cane).

Beneficiaries: 1160 small producers (160 producers in the project area, 500 in the department of Cundinamarca and 500 at the national level).

Objectives

To demonstrate to families of small producers of brown sugar loaf, local authorities, and professional staff from support entities, the potential for a more efficient energy technology to solve the environmental and socioeconomic problems of the sugar loaf agribusiness. The innovation consists of installing a bagasse dosage and heat recovery device in pilot sugar loaf burners. It is hoped that the experience will serve as an input for replication in other sugar loaf production areas of the country and of the region.

2. Project “Design, supply, and installation of a plant that generates 240KW, based on the gasification of the African palm husk”

In Santo Domingo, Ecuador, the processors of African palm oil accumulate the waste of this plant, which they burn in an unrestrained manner. This affects the area for which the National Electricity Corporation (NCEL) is responsible. Families living in this area have limited economic resources and work in the palm plantations or in related activities. This area depends on private generation plants that use fossil fuels and are connected to the National Transmission System for their energy supply.

The company ENERPRO Comprehensive Technical Solutions Co. Ltd. proposed the construction of an electrical 240 KW plant whose power would be obtained from combustion of the residual biomass of the African palm husk. The project would be carried out in Comuna Plan Piloto, in the Santo Domingo de las Tsáchilas province.

Beneficiaries: Comuna Plan Piloto

The project seeks to utilize the waste from the African palm after the extraction of the vegetable oil in order to generate electricity. In addition to testing a new technology, there is an attempt to demonstrate the viability of a joint effort between a private company and the communities, through the implementation of social projects that will bring benefits and development to all participants.

3. Project “Rural Energization” in the Guano and Pujilí communities through the implementation of improved kitchens”

Inhabitants of the high Andean regions of Ecuador live in traditional houses that is, houses built from materials in the area, with little resistance to cold. On average there are seven people per household. One of the most important areas is the kitchen, an area without electric light, and with little ventilation, where smoke accumulates whenever food is prepared since it is cooked with firewood. Not only does this pose an energy problem, but it also leads to families suffering from a huge number of respiratory problems and eye infections.

The Adventist Development and Relief Agency (ADRA) of Ecuador has launched a program to improve the kitchens of these families, in cases where family income is not enough to cover basic needs. Thus, the goal was to protect family health, and the environment as well.

Beneficiaries: 800 families from the cantons of Guano and Pujilí, in the provinces of Chimborazo and Cotopaxi, respectively.

Objectives

Providing the families with two-burner stoves which are safer, easier to handle and economical. This guarantees a healthier environment, which reduces the risk of contracting respiratory and eye diseases.

The project seeks to install a model kitchen that can be replicated in similar areas, and also to develop roadmaps that enable certification and investment in carbon bonds from the use of this technology.

4. Project “Renewable Energy for schools and community centers in the Andean moorland”

The hygiene and health of inhabitants of the Andean moorland in Ecuador are at stake. The lack of hot sanitary water is reason for criticism on the part of those living in the city. But what is even more serious is that it affects school-age children, who suffer discrimination for lack of cleanliness, a situation that undermines their dignity, social integration and self-esteem. Furthermore, these minors are more exposed to infectious diseases that can lead to death from dehydration.

The Ecuadorian Populorum Progressio Fund (EPPF) has created training opportunities and implemented measures related to the use of renewable energies in the high Andean areas of Bolivar, Chimborazo and Cotopaxi. These processes include the distribution of thermal systems (solar panels) to heat clean water in schools and community centers.

Beneficiaries: 42 schools and community centers in the highlands areas of the Andean moor in the Bolivar, Cotopaxi, and Chimborazo provinces.

Objectives

Some 1600 families will have access to hot water generated by solar panels, which will help lower the disease rate. The project seeks to change the hygiene practices of 90 % of children in schools. The systems will be managed by trained staff (including women) to ensure the practice is sustainable, and can generate income for maintenance and repair. Also, and in the hope that more communities will participate in the project, the concept of “solar community” will be spread among participating organizations. Endorsement and funding from the State, by means of the parochial, cantonal, and provincial governments, will be made available.

It is anticipated that the establishment of a local association will ensure the sustainability and continuous development of this technology. To this end, family and/or community savings and a credit system will be put in place to purchase renewable energy equipment.

5. Project “Solar Transfer in the Achuar territory of Ecuador and Peru”

Since ancestral times, the indigenous population of the Achuar nation has used canoes and oars for river transport. This practice is being replaced by the use of light aircraft and motor boats, two modern means of transport that have gained popularity due to the comfort they provide. Currently transportation in the Achuar region is expensive: in the Amazon region gasoline costs approximately six dollars or more per gallon, while in the rest of the country it costs a dollar, not to mention the cost that these changes pose to the environment.

The Pachamama Foundation plans to establish four solar energy recharge centers and to distribute boats with panels and solar batteries to communities on the border of both countries. It will also provide training in management and maintenance of the solar energy system that is to be distributed.

Beneficiaries: Achuar Community from the Pastaza and Morona Santiago provinces in Ecuador, and from Loreto in Peru.

Objectives

This project constitutes a contribution to the national policy of mitigation and adaptation to climate change because it is a replicable model that contributes to the change of the energy matrix. It also helps to activate the local economy by increasing the circulation and the exchange of goods and services in response to increased river connectivity, the expansion of ecotourism, and the use of solar energy.

In environmental terms this initiative contributes to reducing the contamination of rivers and the Amazon forest region, both in terms of the toxic residues being eliminated into them and the sound pollutants that disturb the fauna of the area. Culturally, the

project offers an alternative consistent with the beliefs of the Achuar and their conduct regarding the protection of the jungle.

6. Project “Reducing the Vulnerability of rural inhabitants in the Andean Highlands due to climate change in Cusco”

In the upper Andean communities of Peru, income distribution problems persist due to difficulties in accessing natural resources and exercising the right to own property. This situation is reflected not only in the degradation of the environment, but also in the living conditions of millions of people.

In general, the population of the province of Chumbivilcas, in Cusco, is perceiving changes in rainfall patterns, extreme variations of temperature, and unusually, cold waves that put the health of families at risk. There is also a decrease in the minimum flow of water sources at certain times and damage to agricultural activity from low temperatures. People live in precarious conditions: to prepare food they use firewood or dung, which increases the frequency of respiratory diseases, the main cause of mortality in the province.

The Andean Education and Promotion Center “José María Arguedas” (CADEP JMA) works with the rural families of the districts of Llusco and Quiñota in adapting their dwellings to counteract the negative effects of climate change. It seeks to improve living space by promoting the use of renewable energy resources. Vegetable production under cover is also promoted (*fitotoldo*).

Beneficiaries: 60 families from four rural communities in the districts of Llusco and Quiñota in the province of Chumbivilcas in Cusco.

Objectives

To obtain a model of air-conditioned housing in which the temperature can be raised in the interior using solar energy, as well as the use and revaluation of traditional construction technologies. To this end, local and regional work should be done to avoid state assistance dependency (e.g. avoiding the donation of blankets), and to try and replicate the project in the most vulnerable upper Andean areas.

7. Strengthening efficient energy use in the regions

The National Environmental Fund (FONAM) promotes the efficient use of renewable energies as well as the competitiveness of the SMEs in the rural and suburban areas of Arequipa, La Libertad, Piura and Junín by incorporating them into the carbon market. Such an objective would be achieved through:

- » Regional fairs that would be attended by suppliers of energy efficient equipment, renewable energies, and other stakeholders in the carbon market.
- » Courses-Regional Workshops on energy efficiency, renewable energies, and the carbon market.
- » Energy diagnoses: Energy audits would be carried out and the possibility of using renewable energies and reducing CO2 emissions in selected SMEs would be identified.
- » Partnerships with ministries, regional governments, universities, and local consultants.

Beneficiaries: SMEs, engineers, technical personnel, and workers from the regions of Arequipa, Junín, La Libertad, and Piura.

Objectives

The project promotes good practices in energy efficiency and opportunities for the application of clean and renewable energies, with emphasis on improving competitiveness and environmental sustainability through the strengthening of regional capacities. The aim is to reach trade associations, Chambers of Commerce, small business associations, professional bodies, and/or technical institutes, technical personnel and workers, through diplomas, technical specialization courses in energy efficiency and regional ordinance proposals, as well as creating information centers and diagnostic studies. In this way, it is hoped that a contribution will be made to energy efficiency while boosting the financial capacity of companies.

REFERENCES

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- ASTI (Agricultural Science and Technology Indicators, United States of America); IFPRI (International Food Policy Research Institute, United States of America); CGIAR (Consultative Group on International Agricultural Research, France). n. d. Mission (online, website). Washington, D. C., United States of America. Consulted 10 apr. 2017. Available at <https://www.asti.cgiar.org/about>.
- ECLAC (Economic Commission for Latin America and the Caribbean, Chile); FAO (Food and Agriculture Organization of the United Nations, Italy); IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica). 2013. The Outlook for Agriculture and Rural Development in the Americas: A Perspective on Latin America and the Caribbean 2014. San Jose, Costa Rica, IICA.
- FAO (Food and Agriculture Organization of the United Nations, Italy). 2014. 2014 International Year of Family Farming: Objectives and Lines of Action (online). Rome, Italy. Consulted 11 apr. 2017. Available at <http://www.fao.org/family-farming-2014/home/objectives-lines-of-action/en/>.
- FAO (Food and Agriculture Organization of the United Nations, Italy). 2015a. 2014 The State of Food and Agriculture: Innovation in family farming. Rome, Italy.
- FAO (Food and Agriculture Organization of the United Nations, Italy). 2015b. Foro Regional Latinoamericano. Desarrollo Territorial, Innovación y Comunicación Rural. Declaración final (online). Consulted 5 apr. 2017. Available at http://www.fao.org/fileadmin/user_upload/rlc/eventos/343681/DeclaraciónFinalForo.pdf.
- FAO (Food and Agriculture Organization of the United Nations, Italy); INRA (French National Institute for Agricultural Research, France). 2016. Innovative markets for sustainable agriculture: how innovations in market institutions encourage sustainable agriculture in developing countries. Rome, Italy.
- FONTAGRO (Regional Fund for Agricultural Technology, United States of America). 2017a. Who we are (online). Washington, D. C., United States of America. Consulted 31 jan. 2017. Available at <https://www.fontagro.org/en/who-we-are/our-history/>.

- FONTAGRO (Regional Fund for Agricultural Technology, United States of America). 2017b. FONTAGRO in Brief (online). Washington, D. C., United States of America. Consulted 31 jan. 2017. Available at <https://www.fontagro.org/en/who-we-are/fontagro-in-brief/>.
- French, J; Montiel, K; Palmieri, V. 2014. Innovation in agriculture: a key process for sustainable development. San Jose, Costa Rica, IICA. IICA Institutional position paper.
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica). n. d. a. Proyecto Piñón en Ecuador: Galápagos el gran beneficiario (online). San Jose, Costa Rica. Available at <http://www.iica.int/es/prensa/noticias/proyecto-piñon-en-ecuador-galapagos-el-gran-beneficiario>. From the BID-FOMIN blog.
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica). n. d. b. Proyecto Red SICTA finaliza con grandes resultados en Centroamérica (online). San Jose, Costa Rica. Consulted 31 jan. 2017. Available at <http://www.iica.int/es/prensa/noticias/proyecto-red-sicta-finaliza-con-grandes-resultados-en-centroam%C3%A9rica>.
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica). n. d. c. REDCAHOR (online). San Jose, Costa Rica. Consulted 19 apr. 2017. Available at http://webiica.iica.ac.cr/comuniica/n_4/espanol/al_red.html.
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica). 2010a. Strategic Plan 2010-2020. San Jose, Costa Rica.
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica). 2010b. 2010-2014 Medium-term Plan: Promoting competitive and sustainable agriculture in the Americas. San Jose, Costa Rica.
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica). 2011. Innovation to Achieve Competitive, Sustainable and Inclusive Agriculture. Regular Meeting of the Executive Committee (31, 2011, San Jose, Costa Rica). San Jose, Costa Rica.
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica). 2012. 2011 IICA Annual Report: Promoting competitive and sustainable agriculture in the Americas. San Jose, Costa Rica.
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica); AEA (Alliance Program on Energy and Environment in the Andean Region, Peru); Ministry of Foreign Affairs of Finland. 2012. Proyectos en ejecución de la primera convocatoria del Fondo Concursable AEA 2012 (online). Consulted 25 apr. 2017. Available at <http://repiica.iica.int/docs/B3691e/B3691e.pdf>.
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica); INNOVAGRO (Network for Managing Innovation in the Agrifood Sector, Mexico). 2012. Methodology Guide for the Diagnosis of Agri-Food Innovation National Systems in Latin America and the Caribbean. San Jose, Costa Rica.
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica). 2013a. 2012 Annual Report of IICA: Promoting Competitive Sustainable Agriculture in the Americas - Sowing innovation to harvest prosperity. San Jose, Costa Rica.
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica). 2013b. Programa de agricultura familiar para el encadenamiento productivo (PAF-CP). Plan de Agricultura Familiar de El Salvador. San Jose, Costa Rica. Informe del IICA.
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica). 2014. 2014-2018 Medium-term Plan: Agriculture, opportunity for development in the America. San Jose, Costa Rica. (Official documents series n. 94).
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica). 2015. 2014 Annual Report of IICA. Agriculture, opportunity for development in the Americas. San Jose, Costa Rica.
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica). 2016. 2015 Annual Report: Harvesting Results. San Jose, Costa Rica.
- IICA (Inter-American Institute for Cooperation and Agriculture). 2016. IICA and the EU launch program to address the effects of coffee leaf rust on Central America and the Dominican Republic (online). Consulted 18 apr. 2017. Available at <http://www.iica.int/en/press/news/iica-and-eu-launch-program-address-effects-coffee-leaf-rust-central-america-and-dominican>.
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica); SFM (Sustainable Forestry Management for the Andean Region); MFAF (Ministry for Foreign Affairs of Finland). 2015. Sistematización y viabilidad de innovaciones del Programa Manejo Forestal Sostenible en la Región Andina (online). Consulted 5 apr. 2017. Available at <http://www.forestalsostenibleandina.net/CMSPages/GetFile.aspx?guid=48288c31-8b19-49b8-a835-b0b5d7b8921d>.
- IICA (Inter-American Institute for Cooperation on Agriculture, Costa Rica); PROSAP (Provincial Agricultural Services Program, Argentina). n. d. Convenio IICA-PROSAP (online). Consulted 28 apr. 2017. Available at <http://webiica.iica.ac.cr/argentina/prosap/convenioIICA-PROSAP.pdf>.
- INNOVAGRO (Network for Managing Innovation in the Agrifood Sector, Mexico). 2011. Documento base. Mexico City, Mexico.
- LAICA (Agricultural Industrial League of Sugarcane, Costa Rica). 2012. Departamento de Investigación y Extensión de la Caña de Azúcar (online). San Jose, Costa Rica. Consulted 13 apr. 2017. Available at <https://www.laica.co.cr/investigacion.php>.
- MEER (Ministry of Electricity and Renewable Energy, Ecuador). 2016. Proyecto: K015-MEER - Producción de aceite de piñón para plan piloto para generación eléctrica en Galápagos: ficha informativa de proyecto 2016 (online). Consulted 8 apr. 2017. Available at <ftp://190.152.52.4/LOTAIP/planificacion/SEGUIMIENTO%20GPR%20OCTUBRE2016/PRODUCCIONDEACEITEDEPINON.pdf>.
- Meeting of Ministers of Agriculture of the Americas 2011. 2011. San Jose Declaration of Ministers of Agriculture 2011 (online). Meeting of Ministers of Agriculture of the Americas (2011, San Jose, Costa Rica). Consulted 5 apr. 2017. Available at http://legacy.iica.int/Esp/prensa/Documents/JIA2011Declaracion_eng.pdf.
- Miranda, M. 2013. Family Agriculture Program for the Production Chain (PAF CP). El Salvador Family Agriculture Plan: IICA Report. San Jose, Costa Rica, IICA.
- OECD (Organisation for Economic Co-operation and Development, France). 2013. Agricultural innovation systems: a framework for analyzing the role of the government. Paris, France, OECD.
- OECD (Organisation for Economic Co-operation and Development, France). 2015. Frascati Manual 2015: Guidelines for collecting and reporting data on research and experimental development. Paris, France, OECD.
- PRIICA (Programa Regional de Investigación e Innovación por Cadenas de Valor Agrícola, Costa Rica). 2017. Acerca del PRIICA (online, website). San Jose, Costa Rica. Consulted 31 jan. 2017. Available at http://www.priica.sictanet.org/acerca_del_priica.
- PROMECAFÉ (Regional Cooperative Program for the Technological Development and Modernization of Coffee Production). n. d. PROMECAPÉ: un proyecto tecnológico con trayectoria (online). Consulted 10 apr. 2017. Available at http://webiica.iica.ac.cr/comuniica/n_2/espanol/x_pcafe.htm.
- Proyecto Mesoamérica, El Salvador. 2017. Mesoamerican Integration and Development Project (PROMEFRUT) (online). La Libertad, El Salvador. Consulted 10 apr. 2017. Available at http://proyectomesoamerica.org/joomla/index.php?option=com_content&view=article&id=191&Itemid=120.
- Sonnino, A; Ruane, J. 2013. La innovación en agricultura como herramienta de la política de seguridad alimentaria: el caso de las biotecnologías agrícolas. In Hodson de Jaramillo, E; Zamudio, T. (eds.). Biotecnologías e innovación: el compromiso social de la ciencia. Bogota, Colombia, PUJ.
- Trigo, E; Mateo, N; Falconi, C. 2013. Innovación agropecuaria en América Latina y el Caribe: escenarios y mecanismos internacionales. Washington, D. C., United States of America, IDB. (Nota Técnica IDB.TN-528).
- UN (United Nations, United States of America). 2010. High-level Plenary Meeting on the Millennium Development Goals: Keeping the promise: a forward-looking review to promote an agreed action agenda to achieve

the Millennium Development Goals by 2015. (online). Nueva York, United States of America. Consulted 10 apr. 2017. Available at http://www.un.org/en/mdg/summit2010/pdf/HLPM%202010_CRP_Side%20events.pdf.

UN (United Nations, United States of America). 2015. Open Working Group proposal for Sustainable Development Goals (online). New York, United States of America. Consulted 3 apr 2017. Available at <https://sustainabledevelopment.un.org/processes/post2015/owg/proposal/>.

World Bank, United States of America. 2012. Agricultural Innovations Systems: An Investment Sourcebook. Washington, D. C., United States of America.



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