The Outlook for Agriculture and Rural Development in the Americas:

A Perspective on Latin America and the Caribbean

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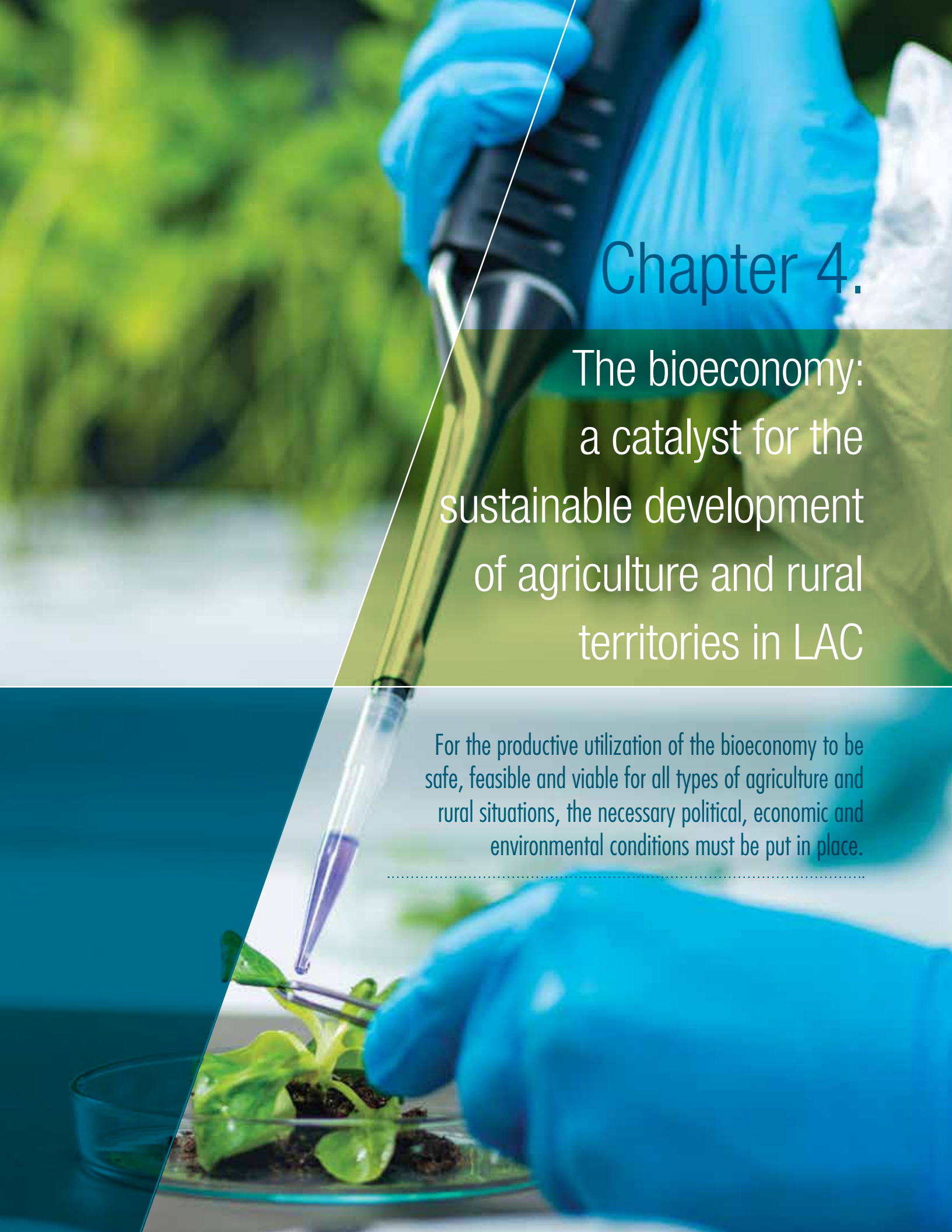


Chapter 4.

The bioeconomy: a catalyst for the sustainable development of agriculture and rural territories in LAC

For the productive utilization of the bioeconomy to be safe, feasible and viable for all types of agriculture and rural situations, the necessary political, economic and environmental conditions must be put in place.

The bioeconomy is a new techno-economic paradigm of production and consumption.

4.1. Introduction

The bioeconomy makes it possible to tap the latest scientific and technological advances in order to make more efficient and sustainable use of biological principles and resources, which are so rich and plentiful in LAC. Although the bioeconomy is a recent concept, the region has been working on these issues for many years. Indeed, the LAC countries have been pioneers, and are now leaders, of some uses of the bioeconomy. There are many successful experiences that can serve as an example and a motivation.

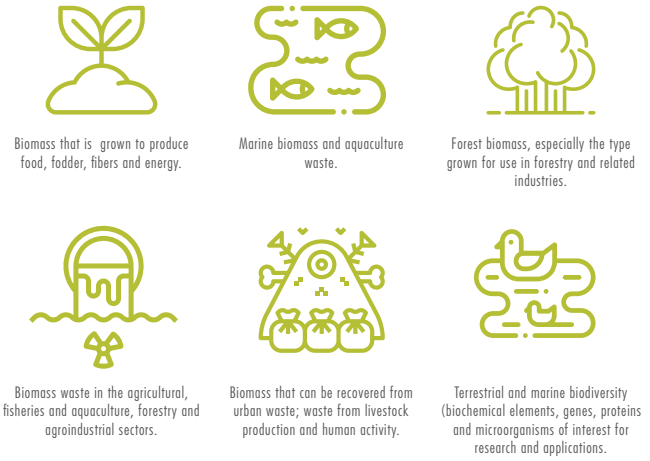
4.2. Context

To develop fully, the bioeconomy needs to construct its own techno-economic system and political-institutional support mechanisms.

4.2.1. What is the bioeconomy?

The bioeconomy has been defined as "the production, utilization and conservation of biological resources, including related knowledge, science, technology, and innovation, to provide information, products, processes and services across all economic sectors aiming toward a sustainable economy" (IAC-GBC 2018, p. 2). This definition highlights not only the potential offered by the development of scientific knowledge (European Commission 2005), but also the potential of the biological base as a driver of development.

Figure 4.1: Biological resources that biodiversity provides



The bioeconomy is a new techno-economic paradigm of production and consumption that is currently being developed following the logic of the previous paradigm, the industrial

revolution and the fossil fuel economy. In order for the bioeconomy to develop fully, therefore, it needs to construct its own techno-economic system and political-institutional support mechanisms.

In that process, there will be losers (e.g., in the fossil fuel economy) and winners (e.g., in new value chains based on biological resources) and it will be up to each country to decide how to strike that balance. Decarbonization of fossil fuels, a core element of the techno-economic model of the bioeconomy, is an objective that is increasingly being mentioned in the regional and national discussions on development policies. Little progress has been made, however, and the issue is only now beginning to be reflected in policy and investment strategies.

The concept of the bioeconomy as a development approach has benefited from advances in science and technology, and from the need to address new problems and concerns. It has appeared, then, just as the industrial revolution and other revolutions appeared in earlier times, boosted by the extraordinary advances witnessed over the last three decades in knowledge and technologies related to the biological sciences, and the complementarity and convergence of the biological sciences and the sciences and technologies of materials (especially nanotechnology) and information (e.g., digitalization, information and communication technologies, and the Internet of Things; see section 3.2.2). All this has contributed to a substantial increase in knowledge of the potential of biological resources and possible ways to harness and make sustainable use of them.

The emergence of the bioeconomy as a development approach has also been driven by the concerns associated with climate change, as the material and energy base of the economy has to change in order to combat it. Since biological resources are its material and energy base, the bioeconomy is crucial for the change of model required to combat climate change. The bioeconomy, which has also emerged in a context of concerns over the sustainability of agriculture — in terms of the use of natural resources and the GHG generated by productive activities—, provides solutions to those concerns, contributing to adaptation and mitigation, but also helping to strengthen the synergies between the two.

The proposed definition of "bioeconomy" highlights four elements:

1. The production, utilization and conservation of biological resources;
2. The knowledge, science, technology and innovation related to the previous element;
3. The production of information, products, processes and services that can be used by all economic sectors; and,
4. The objective of advancing toward a sustainable economy.

In the agricultural sector, these elements are related to:

1. Biomass and genetic resources;
2. Knowledge derived from the biological sciences and the application of biotechnologies and modern technologies related to the bioeconomy (see section 3.2.2); and,
3. An increase in value added and diversification (see section 3.2.5).

The distinctive element of the bioeconomy as a policy framework and a development approach is the fact that biological resources are its material and energy base.

4.2.2. The bioeconomy and the 2030 Agenda

The bioeconomy provides a conceptual framework for the development of strategies designed to tackle the major social challenges and sustainable development concerns contemplated in the 2030 Agenda. More efficient productive and sustainable use of biological principles and resources, thanks to advances in science, technology and knowledge, would make it possible to put forward new economic alternatives, especially in the rural milieu. The latter include the sustainable intensification of agricultural production (see section 3.2.1), biotechnological applications for developing more productive varieties (see section 3.2.2) better adapted to climate change and with improved nutritional attributes, biopharmaceutical products, biofunctionalized materials for medical applications and better education, among others.

It should be noted that bioeconomy activities are not necessarily sustainable. When biological resources and biomass are used to generate foodstuffs for human beings and animals, fuels and biological products, there can be positive and negative environmental and socioeconomic effects. In the context of its work on sustainable bioeconomy guidelines, FAO presented 26 case studies related to sustainable bioeconomy interventions implemented across the globe, which encompassed a broad range of issues and sectors. This diversity reflects the nature of the bioeconomy. Thus, although no single model exists for the development and implementation of the bioeconomy, it is possible to suggest a series of ways of achieving a sustainable transition towards it.

The lessons learned from the 26 case studies give an idea of how the change to sustainability is achieved in practice. They also show clearly that sustainability does not occur automatically. Whenever possible, many actors should join forces to achieve synergies and reduce discrepancies with regard to sustainability goals. These lessons have been structured around six main issues, which are by no means exclusive, associated with most of the bioeconomy's development objectives, namely: food security, natural resource management, climate change, responsible production and consumption, economic growth and good governance (for further details, see Annex 5.8).

4.2.3. Why should LAC focus on the bioeconomy?

The bioeconomy is both an opportunity and a need for LAC. It is an opportunity because the region possesses the two basic ingredients that undergird the bioeconomy:

1. The broad availability of biological resources (biodiversity and genetic resources, diverse productive landscapes, the ability to produce biomass, the generation of biomass from unused waste); and,

2. The scientific and technological capabilities necessary for the development of the bioeconomy, such as the agricultural and biological sciences.

The region also needs the bioeconomy, in view of:

1. The challenge of finding new pathways for more sustainable and inclusive rural and agricultural development (it could help resolve problems of equity, distribution, poverty and territorial imbalance);

2. The urgent need to find alternative forms of mitigation and adaptation for the agricultural sector in response to climate change that also guarantee the sector's sustainability and competitiveness, as well as the inclusion of small farmers; and,

3. The global objective of contributing to the decarbonization of fossil fuels.

The bioeconomy, an opportunity

Viewed as a whole, LAC has a strategic advantage in terms of its endowment of biological resources. Its territory accounts for 13 % of the planet's land mass and is home to 9 % of the world's population. In terms of the world's resources, the region

possesses 50 % of known biodiversity, 21 % of terrestrial ecoregions, 22 % of fresh water, 16 % of marine water resources, 23 % of forests and 57 % of primary forests. It receives 29 % of all precipitation and contains 31 % of the planet's 35 million cubic kilometers of fresh water resources (UNDP 2013). Moreover, LAC is the developing region with the largest proportion of land available per capita that could be incorporated into production activities. Nonetheless, there continue to be significant gaps in productivity in the main crops (Sennhauser et al. 2011).

The situation in the field of science and technology is more diverse. In aggregate terms, in recent decades the region has significantly increased its investment in agricultural R&D, which rose by 75 % between the mid-1990s and 2010. However, most of the increase occurred in the biggest countries —Mexico, Brazil and Argentina— and, to a lesser extent, in Colombia, Costa Rica, Chile and Uruguay—, while the remainder lagged some way behind (Stads, Gert-Jan, Nienke Beintema 2016). The situation is similar in the case of biotechnology (see section 3.2.2), a crucial area for the development of the bioeconomy, with major disparities with other parts of the world not only in terms of the amount invested, but also the performance of the respective systems.

Regional cooperation initiatives on these subjects go back a long way. In the field of agricultural research, some cases in point are those of the Tropical Agriculture Research and Higher Education Center (CATIE), the Caribbean Agricultural Research and Development Institute (CARDI), the cooperative agricultural research programs (PROCIs), the Regional Cooperative Program for the Technological Development and Modernization of Coffee Cultivation (PROMECAFE) and the Regional Fund for Agricultural Technology (FONTAGRO), created with a view to promoting joint efforts to compensate for countries' unequal capacity for investment (Trigo et al. 2019, Trigo 2018). Capacity building initiatives have emerged in the field of new technologies, including the Network of Biotechnology Laboratories for LAC (REDBIO) and the Argentina-Brazil Biotechnology Center (CAABIO), designed as training platforms and for discussion and academic exchanges on scientific and policy matters related to biotechnology development. As a result of cooperation of this kind, initiatives have begun to emerge related to the development of sustainable agricultural production strategies, the use of biotechnology, bioenergy production, biodiversity-based businesses and advances in the development of markets for ecosystem services, which deal with the processes via which the environment produces resources that are essential for human beings (air, water, food and materials). See the case of Natura below (Box 4.6).

The bioeconomy, a need

It is necessary to renew the strategies for integrating rural economies and territories into the global economy, and to define new productive pathways, based on biological resources, that generate jobs and income.

The bioeconomy is an alternative approach of the kind needed to tackle the big challenges facing most countries in the region, especially their rural areas, in terms of food security, poverty and unemployment, among others. In fact, the bioeconomy has two strong

The bioeconomy is both an opportunity and a need for LAC.

arguments in its favor. Firstly, the macroeconomic benefits to be gained from a possible global balance of food, fiber and energy, and a potential improvement in environmental sustainability. And secondly, within the limits of the region, the opportunities for achieving equitable growth offered by the bioeconomy (see Box 4.1), harnessing traditional agricultural production and other forms of biomass (biofactories, for example).

Box 4.1: Social inclusion through better opportunities for rural development.

Rural areas are being undermined by the effects of the emigration of young people and the ageing of the wider population. However, thanks to the possibilities of production being opened up by new technologies and the fact that in many cases value is added locally, the bioeconomy offers new opportunities for the economic development of rural territories. Biorefineries, for example, make it possible to improve and expand many traditional value chains, and look set to provide the springboard for developing new ones. At the same time, a more reliable, decentralized supply of energy could do much to attract new income-generating economic activities to rural areas.

Many of these initiatives work with raw materials that require a smaller investment per unit of product generated than large factories. This means that, for a given level of total investment, they offer greater opportunities in terms of types of activity and employment. This, together with connectivity and the new information and communication technologies (see section 3.2.2), promotes a structure for more diversified links between agriculture and the rest of the economy, thus opening up the possibility of creating new jobs and capacities, and eliminating the reasons why young people do not find rural areas attractive.

In particular, the bioeconomy is of fundamental importance as a forward-looking approach for economies and rural territories, which find themselves needing to review their strategies for integrating into the global economy and defining new productive pathways that will generate jobs and income. The bioeconomy provides interesting alternatives for more balanced and inclusive territorial development, which is vital in order to combat the persistent problems of rural poverty effectively (see sections 2.8 and 3.1.2).

On the other hand, since biomass is a very cheap, voluminous resource in most of its forms, the rate of return is much greater when value is added close to the point of origin. This is especially true if the goal is to optimize its utilization through the development of new value chains associated with the use of "waste" biomass in productive activities with positive territorial externalities (e.g., the energy supply, generation of jobs, reduction of pollutants). The application of new scientific-technological breakthroughs around the productive model of the biorefinery makes the cascade processing of biomass possible in order to produce food and fodder, fibers, energy, biological materials and others bioproducts with high value added. This results in a reorganization of investment processes that, in turn, leads to the economic densification of territories and calls for the development of both a better economic infrastructure (roads, railways, communications, etc.) and social support infrastructure (education, health).

One important aspect of the use of waste biomass is the fact that it makes it possible to generate energy locally, which, in rural territories, could facilitate access to competitively priced energy (SDG 7: affordable and clean energy), the introduction of more efficient equipment, and access to the Internet and other services that improve the quality of life. Furthermore, the processing of local waste and residues can have a positive environmental impact, as it reduces the risk of water and soil pollution in the service areas, in addition to creating synergies for addressing climate change.

Finally, the transition toward development based on the bioeconomy opens up the possibility of abandoning the dichotomy between agriculture and industrial development that has dominated the debate on development strategies in LAC for decades (see section 3.1). The bioeconomy is a production and economic organization strategy for the economy as a whole that includes a wide variety of new, modern and traditional sectors and parts of sectors (family farming, agricultural systems of indigenous peoples, etc.) and various scales of production. What they all have in common is the fact that they share the concept of the use of biological processes and resources as a core component of their production activities and services. The model thus brings about a transformation of intersectoral relations but, even more importantly, provides a significant opportunity to revitalize rural areas.

4.3. The bioeconomy in LAC

The development of the bioeconomy is under way in the region. Legal, institutional and policy frameworks are already in place, and there are pioneering business initiatives on issues linked to bioenergy, biotechnology and sustainable biodiversity use. Pathways have also been identified for the development of the bioeconomy with a regional vision (Hodson 2015, Hodson de Jaramillo et al. 2019) and several countries are developing national and subnational strategies on the subject (see section 4.3.2).

4.3.1. Technological and productive advances

LAC has made important progress in areas such as bioenergy, agricultural biotechnology, low-carbon agriculture, the utilization of biodiversity and ecosystem services, as well as with the development of a circular bioeconomy.

Bioenergy

Bioenergy, especially liquid biofuels (mainly bioethanol and biodiesel) and biogas, is an important part of the decarbonization strategies under discussion within the framework of the 2015 Paris accords. This is an area in which the LAC countries have major advantages, not only in terms of the raw materials needed to produce energy of this kind, but also the development of both national and international markets.

From the standpoint of the bioeconomy, biofuels are a strategic platform. As well as helping to create a cleaner energy matrix, with respect to both the vehicle fleet and the production of electricity, the biorefineries that produce them could have a multiplier effect on other sectors of the economy, such as green chemistry (platform chemicals and specialties, plastics, cosmetics, etc.), fertilizers and other industrial inputs, and consumption products. Joint production and the circularity of the biorefinery model is an aspect that makes it possible to reduce biofuel production costs and make such fuels more competitive with fossil fuels, and to consolidate and enhance their virtual environmental benefits (Clark et al. 2012).

Bioethanol. In all the countries, the development of ethanol production has been closely associated with public policies, through different programs designed to promote and regulate it.

Brazil and Argentina, and to a lesser extent Colombia, Peru and Mexico, are the countries that have made most progress with both production and market penetration, and development across every link upstream and downstream from the primary production of the production chains involved (see boxes 4.2 and 4.3). In the other countries of the region, development has been more recent and on a smaller scale, although in the past few years Colombia and Peru have reached quite important levels of production that basically have involved the processing of sugarcane.

Biofuels are a strategic platform for the bioeconomy, not only because they help to create a cleaner energy matrix, but also on account of the possible multiplier effect of biorefineries on other sectors of the economy.

Thus far, 14 countries in the Americas have established a mandate of some kind for the blend of ethanol and fossil fuels, ranging from 5 % to 27 % (REN21 2019).

In Colombia, there are seven plants that produce sugar and ethanol together and co-generate electricity. The volume produced is around half a million liters per year, and it is estimated that the industry —concentrated mainly in the Cauca Valley— has created some 188,000 direct and indirect jobs (ASOCAÑA 2017).

In Peru, three processing plants are in operation, with production now exceeding 150 million liters per year, focused especially on the domestic market, but with small but growing amounts exported to neighboring countries, and even some in the European Union (EU) (Nolte and Luxbacher 2016). In Central America, Guatemala is the leader in the sector with a productive capability of around 250 million liters per year, most of which is exported to Europe and the United States (Horta Nogueira 2006). In Mexico, production is still insubstantial compared with the sugarcane sector's productive potential.

Box 4.2:
Argentina's experience in producing and exporting bioethanol

The development of ethanol in Argentina is based on sugar production, located mainly in the provinces of the northwest of the country, where the best agroecological conditions are to be found for growing the crop. In 2006, the country enacted the Law for the Promotion and Development of Biofuels (Law No. 26,093), which established that by 2010 fuels were to contain 5 % of bioethanol. Since then, an important process of diversification of production (in terms of both crops and production areas) has taken place, with strong growth in the production of corn ethanol. In 2017, the industry consisted of 14 industrial ethanol plants —9 that process sugarcane and 5 that use corn as the raw material— with a total installed production capacity of some 1.5 billion liters and production of around 1.1 billion liters, with each of the two crops accounting for half of the total (Agromaker 2017).

Box 4.3:
Brazil's experience in producing and exporting bioethanol

In terms of markets, Brazil, with nearly 3.1 billion liters in 2018, is the world's second biggest producer, behind the United States, and the number one exporter of sugarcane ethanol. The process in that country dates from 1975, when, in response to the first oil crisis, the Proálcool Program was launched to reduce the country's dependency on imported oil. It is estimated that sugarcane and its byproducts are now the most important source of primary energy in the national energy matrix, and ethanol consumption has replaced half of the gasoline sold, at a competitive price. This percentage is expected to continue to grow, at least until the middle of the next decade (Ministry of Agriculture and Supply 2009).

The productive platform of the Brazilian sugarcane ethanol industry is made up of a wide variety of biodistilleries that process sugar and ethanol separately or together. A large number of them also use the resulting bagasse to produce electricity for their own consumption —making them self-sufficient in energy— or for use on the national network. This industrial development has had spillovers, both in the production of sugarcane (new varieties have been developed that produce more ethanol) and in the production of inputs and capital goods used in the production of ethanol, and the country has become one of the market's strategic benchmarks (Cortez et al. 2012). As well as these benefits, it is estimated that the sugarcane-ethanol complex generates around 400,000 jobs per year (REN21 2019).

Biodiesel. Regional production is spearheaded by Brazil and Argentina, which have some 80 refineries between them. In Argentina, most of the refineries are to be found around the port of Rosario, while in Brazil the production areas are distributed more widely. Boxes 4.4 and 4.5 describe Brazil and Argentina's experience in producing biodiesel.

In the other countries, there are, in some cases, sizable palm oil plantations (Guatemala, Peru, the Dominican Republic). Biodiesel production is not a significant activity, however, although most countries have mandatory policies covering traditional diesel, with the need normally being met with imports (Gestión 2018). Colombia recently became the only Latin American country to use palm oil diesel to obtain the compulsory biofuel mixture (10 %) and is the leader in Latin America in the production of biodiesel from that source. The palm oil and biodiesel industry has grown notably over the last decade, with the cultivated area, in 2017, reaching more than 400,000 ha., contributing raw material for 11 processing plants. That same year, those plants produced 513,000 tons of biodiesel to meet domestic demand and exports. Most of the plants are located in the north of the country (Fedebiocombustibles (National Biofuel Federation of Colombia) 2019).

Box 4.4:
Biodiesel production in Brazil

Brazil currently produces 5.35 million metric tons of biodiesel per year, placing it among the world's top three producers. The country is preparing for a substantial increase in demand as a result of new legislation that establishes the compulsory use of the B15 blend by 2023 (the blend currently stands at 10 %), and approval of B100 on a voluntary basis for special fleets, such as city buses.

It is estimated that some 600,000 additional tons of soybean oil will be required to meet those requirements, which will mean processing a further of 3.3 million tons of soybeans. In 2015, 76.5 % of the biodiesel produced in Brazil was made with soybeans, 19.4 % with animal fat, 2 % with cotton and 2.4 % with other types of raw materials, such as used kitchen oil and oil palm, among others (De Oliveira 2016).

Box 4.5:
Biodiesel production in Argentina

As many as 37 biorefineries that process soybeans currently operate in Argentina. They can handle 4.4 million tons per year, and in 2016 produced 2.6 million tons of biodiesel, of which 1.6 million were exported, making the country the world's leading exporter (Calzada and Molina 2017). These numbers have been adversely affected in recent years by the emergence of trade conflicts sparked by the potential competition between biofuels and food, and the fiscal policies applied in Argentina. However, this development has also had some positive effects within the industry, since, as a result of falling demand, greater efforts have been made to find other options.

In the provinces where production takes place, fossil fuels are now being replaced by biodiesel in the fleets of public transportation vehicles, which will help stabilize demand and have significant environmental benefits. There is also a trend toward the local use of biodiesel in waste collection (Clarín 2019) and for the agricultural machinery used in different stages of primary production (Fernández and Aguer 2017). All this helps to create virtuous environmental circles at the local level.

In Argentina, genetically modified crops —usually referred to as genetically modified organisms (GMO)— make up almost 100 % of the cultivated area planted with both soybeans and corn and cotton (Trigo 2016). The same is true of Brazil, where the percentage of adoption is higher than 85 % of the cultivated area in all three cases (soybeans 92.3 %, cotton 94 %, and corn 86 %). (CIB and Agroconsult 2018).

Because of its diversity with regard to areas of application, biotechnology is one of the key technologies for the development of the bioeconomy.

Agricultural biotechnology (see also section 3.2.2)

Because of its diversity with regard to areas of application, biotechnology is one of the key technologies for the development of the bioeconomy. It is of strategic importance not only for the improvement of all forms of biomass production, but also because it is a crucial technological pathway for the development of new, more efficient processes that help make it even more valuable. Agriculture in the region has been one of the early adopters of technologies of this kind: in Argentina, herbicide tolerant soybeans were introduced in 1996 (Trigo and Cap 2006). Since then, a significant number of countries have adopted this type of crop (Paraguay, Brazil, Uruguay, Bolivia, Colombia, Costa Rica, Honduras and Mexico), with more than 80 million ha. now planted with different varieties of improved soybeans, corn and cotton to increase yields in response to various biotic and abiotic constraints. All this forms part of processes that are clearly identified with efforts to strengthen the region, positioning it in international markets of these products and accounting for a significant flow of economic and environmental benefits for the countries and sectors involved (ISAAA 2018b).

These processes are even more important given the dynamics of adoption that technologies of this kind have had in the different countries, especially in Argentina and Brazil.

These processes have had a significant economic and environmental impact. As far as the economy is concerned, it is estimated that in the 20 years since they were introduced in Argentina (in 1996) and up to the 2015/2016 farming year, the cumulative direct benefits in terms of increased farmer income have been close to USD 50 billion, with the lion's share (USD 37.5 billion) concentrated in Argentina (more than USD 21 billion) and Brazil (more than USD 16 billion). These countries are first adopters or those that devote most land to crops of this kind (Brookes and Barfoot 2017). The environmental benefits stem mainly from reduced use of agrochemicals and the interaction between technologies of this kind and greater use of reduced tillage practices, topics addressed below in the section on low-carbon agriculture. The scale of these processes, and their effects on the rest of the economy, have proven valuable both at the national and international levels, given the impact that these transformations have had on the food supply and, therefore, on the well-being of global consumers (Trigo 2016).

It should be emphasized that the possibility of the region being an early adopter of biotechnology was closely related to the fact that, when these practices began to become available at the international level, the region already had the institutional bases required to incorporate them into production systems. This was true of both the scientific and technological base and biosafety regulatory systems —which are essential to make new technologies available and provide access to them— and national plant breeding and improved seed systems, which are key to ensuring that genetic innovations reach production systems (for a more detailed analysis see Trigo et al. 2013).

This array of experiences, capabilities and regulatory and market environments has evolved and there is now a variety of crops with new biotechnological developments ready for production and marketing, or near-market research, that are the result of public and private sector initiatives in the region itself. A case in point is the wide variety of modified crops designed to overcome different types of limitations, such as beans tolerant to the golden mosaic virus, potatoes resistant to the PVY virus, alfalfas tolerant to herbicides and with less lignin content, soybeans and wheat tolerant to drought, sugarcane resistant to herbicides and with a bigger energy yield, and even modified safflower seeds to extract chymosin, as part of a biorefinery (see Box 4.8)).

In this process, it should be noted that these developments —which undoubtedly will be strategically important to achieve a new balance between higher productivity and sustainability in the region's traditional products— are being accompanied by a very dynamic process of creating new companies aiming to capitalize on the value to the markets of the new knowledge and technological advances available today for a wide variety of issues and products. This is taking place to a greater or lesser extent across practically the entire subcontinent, from Mexico to the Southern Cone countries, initially with a strong emphasis on matters such as micropropagation in flowers and various tropical crops.

For some time, the aforementioned topics have been evolving towards more complex applications: the production of drugs from biodiversity resources; the use of agroindustrial residues to produce bioinputs and energy, polymers and biodegradable plastics from different cheap substrata, and environmental rehabilitation through the functional optimization of microrganisms. More recently, biotechnological artificial intelligence has begun to be used to create proteins and enzymes to meet specific industrial needs and to "reimagine food" and create foodstuffs similar to conventional ones, but adapted to special segments of consumers (e.g., vegan and celiacs). Also worthy of mention are diagnostic services and assisted human fertilization and the development of biofactories for the use of animals or plants to produce drugs, industrial inputs and food with specific characteristics (processing of cattle for the production of the human growth hormone) or plants for the production of chymosin for the cheese industry (Hodson de Jaramillo et al. 2019).

This suggests that the scientific and technological-productive platform linked to biotechnology is entering a new stage in its cycle of development, particularly bearing in mind the many opportunities created by what has been dubbed "precision biotechnology" and the possible impact on production systems and the ways in which biomass and biodiversity resources are used. In the region, Argentina has taken the lead by adopting a regulatory philosophy based on the idea that precision biotechnology products do not need to be regulated any differently than conventional ones, provided they do not contain foreign genetic material. The other countries in the region supported this position in a recent presentation (ICCA 2018) to the WTO (see section 3.2.2).

Low-carbon agriculture

Agriculture is one of the sectors that contributes most to GHG emissions in the region. Therefore, any decarbonization strategy that is to be implemented should tap the potential of production and the comprehensive use of biomass in the context of a circular bioeconomy. Progress has already been made with the development and adoption of alternative approaches for low-carbon agriculture and significant results achieved, although they vary between sectors and countries. Low-carbon agriculture is often referred to as "conservationist agriculture," a concept that includes a wide variety of production strategies (direct seeding, reduced tillage, greenhouse production, crop rotation) whose general objective is to strike a balance between productivity and sustainability, with the aim of achieving sustainable increases in productivity while at the same time improving the quality of productive resources. Practices of this kind are fairly well established in most countries of the region and have been the focus of major public and private sector R&D efforts, as well as public policies and international cooperation programs. Unfortunately, the information available about the scale of adoption of these practices is limited and incomplete, making further observations impossible. But certain practices are widespread, with direct seeding a case in point. In the Southern Cone countries, a very high percentage of the main crops planted under extensive farming systems use the practice. It has been estimated that around the start of this decade, practices of this kind were being used on some 66 million ha. of farmland in those countries, 31.8 million and 29.2 million in Brazil and Argentina, respectively, with the remainder distributed among Paraguay, Uruguay,

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Bolivia, Venezuela, Chile, Colombia and Mexico (Kassam et al. 2015) (see also the agroecology section in 3.2.2).

Given its scope, one very important case in the region is the Sectoral Climate Change Mitigation and Adaptation Plan to Consolidate a Low-Carbon Economy in Agriculture (Plan ABC), adopted in 2011 in Brazil (see the box corresponding to this country in the next section). Other significant initiatives include the one implemented in Costa Rica aimed at improving the performance of certain sectors with regard to emissions and carbon fixation. This is related to the Nationally Appropriate Mitigation Actions (NAMAs) in the coffee sector (the first in the world in an agricultural sector) and the livestock sector, both of which are ongoing. The NAMA for the coffee sector includes a reduction in the use of nitrogenous fertilizers, promotion of the efficient use of water and energy in processing plants, the fostering of agroforestry systems, and waste management. The NAMA for livestock farming is designed to promote the implementation of technologies and measures for climate change adaptation and mitigation, help producers increase their productivity and income.

In the case of livestock production, the experiences in the region refer to a set of technologies and policies aimed at improving economic and environmental performance. The following are some of the programs and initiatives under way:

1. **Argentina:** Ecological beef certification systems.
2. **Bolivia:** Program for the Sustainable Development of Cattle Farming.
3. **Brazil:** Carbon Neutral Meat Seal, Program for Energy Efficiency of the Resources of the Beef Supply Chain.
4. **Chile:** Conservation and Sustainable Use of the Patagonian Steppe for Sustainable Livestock Production.
5. **Colombia:** Sustainable Livestock Production.
6. **Paraguay:** Agreement for the creation of a sustainable livestock production and technology transfer in the region, Program for the intensification of the livestock production of Mennonite cooperatives.
7. **Uruguay:** Climate smart agricultural production and land restoration on Uruguayan pastureland, and sustainable Uruguayan livestock production systems based on the guidelines of the FAO Livestock Environmental Assessment and Performance (LEAP) Partnership (FAO 2018).

All these initiatives are underpinned by institutional frameworks and policies (see section 4.3.2) designed to send signals to the productive sectors that they need to adjust their activities to the emerging decarbonization priorities, which still are not reflected in the price systems of current markets. From the standpoint of the future of the bioeconomy, these institutional frameworks and promotion efforts are an important asset, as they not only aim to make a key sector of the region's economies more competitive, but also serve as pilot experiences for other strategic sectors.

Sustainable productive and commercial use of biodiversity and ecosystem services

The sustainable productive-commercial use of biodiversity and ecosystem services (Hodson 2015, Rodríguez et al. 2019) focuses on areas associated with the sustainable use of biodiversity. This encompasses efforts such as the recovery of traditional seeds, the discovery of functional traits related to specific uses, the development of new products through innovative processing and the development of markets for local products. In most of these cases, the distinctive feature is the value placed on biodiversity (for example, domestication, transformation, market linkages). In the case of ecosystem services, this includes processes through which the environment produces resources that are indispensable for humans, such as air, water, food and materials. Box 4.6 describes the case of Natura, which illustrates this point.

Box 4.6: Natura: A successful case of sustainable use and valuation of biodiversity.

Natura is a Brazilian multinational company founded in 1969 and dedicated to the manufacture and sale of cosmetics based on natural products, with an emphasis on Brazil's biodiversity. The company's product lines include body soaps, cosmetics and sun care and protection products, creams, perfumes and childcare products. Around 88 % of Natura's products are made with plant ingredients and 12 % are made with native products, extracted from the Brazilian Amazon.

Natura is characterized by its capacity to innovate. It has brand and copyright protection, has been granted 11 model and design patents and has obtained B corp, ISO 27.002:2013 (Information Security) and Carbon Neutral Program certifications. Since 2014, Natura has formed part of the Dow Jones Sustainability Index (DJSI), the New York Stock Exchange. It is also a referent for investors who consider socio-environmental issues in their decisions.

The company works under an open innovation model and develops new digital products for the business. With the launch of the Ekos line in 2000, Natura was the Brazilian company that made a commitment to share the benefits generated by innovation through access to genetic resources and traditional knowledge of local communities. About 3 % of the firm's annual income is invested in innovation. It has signed agreements for the supply of natural assets with farms, businesses and communities in Brazil and LAC. Approximately one-third of these are with traditional communities and local suppliers of genetic resources with traditional knowledge of native species.

The use of socio-biodiversity inputs is based on Natura's Policy on Sustainable Use of Socio-biodiversity Products and Services, which ensures the fair distribution of benefits among the communities that supply these and the sustainable management of assets. Through the Amazonia Program, Natura also seeks to promote the development of sustainable businesses. Together with other organizations, it is working toward the approval of new legislation on access to biodiversity.

Given the special relationship that exists between natural resources and social and economic activities based on the bioeconomic approach, the inclusion of ecosystem services should be a crucial component of any strategy that seeks to promote the sustainable bioeconomy. See section sustainable (Section 3.2.2).

Circular bioeconomy, valuation of waste and residues

The term circular bioeconomy was coined to emphasize the element of circularity in the bioeconomy, highlighting the convergence between both concepts in relation to the full utilization of biomass, under the concept of bio-refinery (OECD 2018). Thus, the concept of the circular bioeconomy is intimately associated with the development of new production activities based on the use of residual biomass (for example, from agricultural and forestry processes) and waste (including domestic waste). Boxes 4.7 and 4.8 describe the experiences of two companies: one in Mexico and the other in Argentina.

Box 4.7: BIOFASE (Mexico): Production of biopolymers based on avocado seeds

The history of BIOFASE dates back to the time when its founder, Scott Munguía, was a student of Chemical Engineering at the Monterrey Institute of Technology and Higher Education (Mexico). In 2011, after years of researching bioplastics, he managed to isolate a polymer from avocado seeds, a technological breakthrough that led him to establish his own company. His firm manufactures sustainable products using abundant resources that have no other use - in this case, the seeds or pits avocados. Mexico is the world's leading producer of avocado, producing more than one million tons annually, from which around 25,000 tons of seed are discarded each month in Mexico alone. In 2014, BIOFASE was recognized as the Innovation of the Year in Mexico by the Massachusetts Institute of Technology (MIT) and as the best green company in Mexico by the National Bank of Mexico Citi Banamex (Banamex).

In 2015, BIOFASE opened its first plant producing only bioplastics. In 2016, in order to diversify production, it opened a second plant that produces cutlery and straws. At present it manufactures between 300 and 400 tons of those products annually, which are exported to the United States, Spain, the United Kingdom, Canada and some Central American countries (El Espectador 2019).

BIOFASE's products consist of 60 % biopolymers made from avocado seed and 40 % of synthetic organic compounds that give these certain mechanical and physical properties. The company also makes biodegradable products, which are re-incorporated into Nature at the end of their useful life and compostable products, which can be discarded in a composter or landfill so that they degrade 100 %. One important benefit of these products is their low carbon footprint, much lower than that of other plastics and bioplastics, due to the phenomenon of the biogenic carbon bonus (as it grows, the avocado tree absorbs CO_2 from the atmosphere to form its tissues (BIOFASE).

Box 4.8: Porta Hermanos: the bioeconomy in agriculture.

Porta Hermanos is a family firm founded in 1882, in Córdoba, Argentina, by Italian immigrants. Originally a producer of liquors, over the years the company has expanded its range of products and diversified its areas of operation.

It has produced two technological innovations. The first is the development of the MiniDest plants, small modular distilleries that are automatic and remotely operated, designed to add value to primary production. These plants are installed on farms in order to produce corn ethanol and animal feed, thereby adding value at the point of origin, integrating agricultural and animal feed production. For each unit of energy used - from the planting of the corn to the production of ethanol – 2.6 energy units are generated. The plant has capacity to process 40 t of corn/day (14,000 t/year, can feed a herd of 4000-6000 head of cattle, which implies a requirement of 1,600 hectares of maize production. The plant produces 15 000 l/day of ethanol and 40,000 kg of distillers' grain.

The second innovation is the design and construction of a safflower bio-factory for the production and global marketing of chymosin produced from safflower (SPC), with capacity to develop plant-based industrial inputs and products transformed through biotechnology (genetically modified safflower). The industrial plant has an annual milling capacity of 6,000 t of safflower, representing around 2 million liters of chymosin (20 % of the global market).

Source: Jose Porta 2018 in (CEPAL 2019d)

Knowledge-based bio-enterprises

As explained in section 4.3.2, startups and SMEs are often pioneers and drivers of innovation in the bioeconomy. And often the greatest innovations - especially in different areas of "cutting-edge" knowledge-based technologies - are developed by young entrepreneurs. Below is a description of two examples, both associated with the use of waste (Box 4.9).

Box 4.9:
Adding value to aquaculture waste, Kura Biotec, Chile

Kura Biotech is a biotechnology company based in Puerto Varas, in southern Chile, and specializing in enzymatic catalysis, which exploits the potential of natural enzyme sources present in that country. The company was founded by Manuel Rozas and began by analyzing and extracting glucuronidases from red abalone (Haliotis rufescens) for the hydrolysis of clinical and forensic drugs. The initial motivation for the firm's development and location in southern Chile was the fact that the region has the world's largest concentration of salmon production and also produces other types of seafood (red abalone, for example), and therefore it set out to add value to the waste from that industry. Given the sophisticated nature of its products, the company focuses on the international market. It currently exports to 14 countries. Its products are used in more than 6 million analyses each year and it works with the world's two best toxicology laboratories. At the beginning of 2018, the firm employed 15 workers, most of them young Chilean scientists, specialists in enzymatic catalysis.

As part of its commitment to the local community, each year the company donates 1 % of its total sales or 10 % of its earnings, whichever is greater, to initiatives that support environmental conservation through activities such as recycling, reforestation or other ecological programs. It also supports social causes, such as community development, as well as drug rehabilitation, education, sports and cultural programs, etc.

Source: Based on Manuel Rosas (CEPAL 2018).

4.3.2. The development of strategies and policy frameworks

Although the region has clearly made strides in relation to the concept of bioeconomy, the fact is that today no country in LAC has a strategy for the promotion and development of the bioeconomy. Below is a summary of current initiatives in Argentina, Brazil, Colombia, Costa Rica, Ecuador and Uruguay.

Argentina

The institutional and policy frameworks for the bioeconomy have two antecedents: a) the early development of biotechnology and, particularly, the early adoption and local development of GMOs in the production of grains and oilseeds, the massive use of low carbon agricultural systems and the dynamic production of vegetable oils, biofuels and industrial products derived from the bio-refineries (these sectors are the main drivers); and b) the country's early involvement in the global discussion on the potential of the bioeconomy as a vision for sustainable development, which took place in the context of the ALCUE cooperation projects (Trigo et al. 2019).

In biotechnology, the main policy and institutional milestones include the creation, in 1991, of the National Biosecurity Commission of CONABIA, which facilitated the early exploration of the potential of these technologies for production development; and the high profile given to these in the national science and technology plans, particularly from 2005 onwards. In this sense, the "Argentina Innovadora 2020" Plan defines the priorities for the 2012-2020 period, based on the convergence between sectors of socio-economic importance (e.g. agroindustry, environment and sustainable development,

energy, industry, health and social development) and general-purpose technologies (biotechnology, nanotechnology and ICT).

The development of biofuels is associated with the introduction of incentives for value aggregation, first through the establishment, during the early 1990s, of tariff differentials to encourage these types of activities and subsequently, through the approval of the Regimen for the Regulation and Promotion of Production and Sustainable Use of Biofuels, established in Laws 26.093 and 26.334 of 2006 (Boxes 4.2 and 4.5).

In strategic-institutional terms, since 2013, the National Government, specifically the Ministry of Science, Technology and Innovation (MINCYT) and the Ministry of Agroindustry (MINAGRO, has undertaken a process to position the bioeconomy as a vision for sustainable development and as a basis for a new strategy for the country's insertion in international markets (Bioeconomia Argentina 2017). This process led, in 2o16, to the establishment of mechanisms for the coordination of policies, programs and projects at the level of the central government, with the aim of organizing and enhancing actions toward the development of the national bioeconomy. The process began at the end of that year and currently work is under way on a proposal for a national bioeconomy strategy (Bioeconomia Argentina 2017). In that context, MINAGRO also decided to create, within its own sphere, the National Bioeconomy Program, as a specific mechanism for coordinating its activities.

These public sector efforts have been accompanied by the private sector through specific declarations and actions, including the creation of the Bioeconomy Group, led by the Buenos Aires Grain Exchange, one of the country's oldest financial institutions (Bioeconomia Argentina 2019), as a specific private-sector space, dedicated to promoting investment in areas linked to the bioeconomy (Group Bioeconomy 2019).

Brazil

The process in Brazil has been dominated by developments in the bioenergy sector and by the aggressive institutional framework implemented to accelerate the development and use of ethanol and biodiesel as fuels. This has served to leverage the Brazilian bioeconomy, since its impact has extended beyond this sector and has led to advances in other areas, such as agriculture, genetic engineering and the capital goods industries, etc. (Boxes 4.3 and 4.4). Thus, the National Alcohol Program (Pro-Alcohol) and the National Program for the Production and Use of Biodiesel (PNPB) may be considered as central elements of the institutional framework of Brazil's bioeconomy.

In the agricultural sector, a very important initiative is the ABC Plan, led by the Ministry of Agriculture, which provides low-interest loans to farmers wishing to implement sustainable agricultural practices and climate-resilient technologies. This Plan aims to reduce greenhouse gases, by 2020, by 160 million tons of equivalent CO2 annually (CCAFS 2019). The objectives of the ABC Plan were incorporated and expanded in the Nationally Determined Contribution of Brazil (2015) under the United Nations Framework Convention on Climate Change (UNFCCC), which proposed to strengthen the ABC Plan to achieve, by 2030, the restoration of 15 million hectares of degraded land and increase the area under the zero tillage regime to 33 million hectares (Zanetti et al. 2015).

For its part, the National Biofuels Policy (RenovaBio), which enters into force in 2019 and aims to decarbonize transport, differs from traditional measures in that it does not propose the creation of a carbon tax, subsidies, presumed credit or volumetric requirements for the addition of biofuels to fuels. Instead, the program will operate based on: i) the definition of national targets for the reduction of emissions of the fuel matrix, for a period of ten years, broken down into individual targets for each year for fuel distributors, according to their share of the fossil fuels market; and ii) the certification of biofuel production, assigning different data for each producer, in a value inversely proportional to the carbon intensity of the biofuel produced. Similarly, the policy established the biofuel decarbonization credit (CBIO), which will be a financial asset traded on the stock exchange, issued by the biofuel producer, based on their commercialization. Also under implementation are several somewhat uncoordinated initiatives, which sometimes overlap or are independent, but which together are beginning to shape an institutional framework with its own identity.

The central element of this framework is the Action Plan in Science, Technology and Innovation (PACTI) in Biotechnology, launched in 2018 by the Ministry of Science, Technology, Innovation and Communication (MICTIC). It aims to produce and apply scientific and technological knowledge to promote social, economic and environmental benefits, cover essential knowledge

gaps, foster innovation and create conditions to promote the strategic insertion of Brazil's bioeconomy within the global context. The Plan's thematic lines are defined according to the production rationale of the bioindustries (biomass processing, bio-refineries, bioproducts). It also proposes to create the Brazilian Bioeconomy Observatory and a Central Coordination Board for the Bioeconomy.

In May 2019, the Ministry of Agriculture, Livestock and Supply (MAPA) launched the Program Bioeconomy Brazil-Sociodiversity, aimed at organizing production systems based on the sustainable use of biodiversity products and the selective extraction of forest products. Finally, in June 2019, the Brazilian Parliament launched the Parliamentary Front for the Bioeconomy, made up of 212 deputies and 12 senators, with the aim of creating the conditions to encourage more economic activities using renewable biological resources in the country.

In line with these advances, in 2014 the country's business sector created the Brazilian Association for Bio-innovation (ABBI), with the mission of promoting a favorable economic, social and institutional environment for innovation and the sustainable development of the advanced bioeconomy in Brazil.

Colombia

The introduction of the bioeconomy concept in Colombia, and its corresponding policy and institutional adaptations, dates back to mid-2011, when the country participated in the ALCUE-KBBE project, which served as a platform to introduce, validate and expand this concept with all the stakeholders involved. This led to the development of the first public policy instrument directly linked to the issue, the Policy for the Commercial Development of Biotechnology based on the Sustainable Use of Biodiversity (CONPES document 3697, 2011). This sought to create the necessary economic, technical, institutional and legal environment for the development of businesses and commercial products based on sustainable biodiversity use, and to allocate seed capital to small and medium-sized businesses of this sector. Even though it did not achieve its goal in practical terms, due to the lack of financial resources to make it viable, the institutional context in which it took place was important.

Subsequently, in April 2017, the First National Forum on the Bioeconomy: Sustainable Local Innovation, was held in Bogotá, resulting in the first concrete proposal to consider the bioeconomy as an engine for comprehensive development in Colombia (Henry et al. 2018). In addition, synergies were created with two new public policy instruments that were then under implementation: The Green Growth Policy (CONPES document 3934, July 2018) and the Strategy for the Implementation of the Sustainable Development Goals (SDGs) in Colombia (document CONPES 3918, March 2018).

The Green Growth Policy has two basic objectives: a) to prioritize those sectors considered strategic for the bioeconomy in Colombia; and b) to propose policy guidelines, strategies and recommendations to position these. This process resulted in an Action Plan for the Bioeconomy, that included proposed guidelines and strategies on governance, R&D capabilities, financial resources, markets and regulatory aspects.

The creation of policy instruments and of formal governmental mechanisms that directly and indirectly favor the development of this area continues and has been consolidated in the "National Development Plan 2018-2022: Pact for Colombia, Pact for Equity", which presents the country's shared vision and shared actions on the bioeconomy's role in environmental sustainability, science, technology, innovation and the development of the Colombian Amazon. These policy instruments were strengthened in February 2019 with the creation, by the National Government, of the "Mission of Experts", a group of 34 leading national and international experts, whose objective is to produce, by December 2019, a roadmap and recommendations for prioritizing science and technology, based on criteria of equity, taking into account both the National Development Plan and the achievement of the Sustainable Development Goals (SDGs). One of the Mission's eight focal areas is "Biotechnology, the bioeconomy and environment", with the task of revising previous erroneous concepts, eliminating conceptual limitations and presenting real new horizons in the medium and long term for Colombia in this thematic area (Presidency of the Republic of Colombia, 2019).

The consolidation of these advances has involved the joint recognition by academia and the public and private sectors —including production associations—of the urgent need to reconcile the current production model with criteria of economic, environmental and social sustainability, and the enormous potential offered by the bioeconomy in efforts to achieve that objective (National Bioeconomy Forum, Innovation Territorial Sustainable, April 27, 2017), and the political endorsement

given to this issue through its inclusion in both in the National Development Plan 2018-2022 and in one of the thematic areas of "Mission of Experts."

Costa Rica

Conscious of its biological potential and of its considerable scientific and technological capabilities in this field, Costa Rica — through its Ministry of Science, Technology and Telecommunications (MICITT)— has drafted a national bioeconomy strategy that is based on a solid institutional and legal framework, and is in line with international regulations in this area.

Since the mid-1990s, Costa Rica has developed major public policy initiatives for the development of the bioeconomy (Aramendis et al. 2018). In the agricultural sphere, the main policies are the Nationally Appropriate Mitigation Actions (NAMA) in the coffee and livestock sectors, and a NAMA for the energy-biomass sector, as part of the VII National Energy Plan 2015- 2030, whose objective is to encourage the utilization of organic agricultural residues from the agricultural and agroindustrial sectors for the creation of clean energies.

In the area of R&D, the country has more than 30 research centers in biological sciences, sustainability and other areas of interest for the development of the bioeconomy in its public universities —the Instituto Tecnológico de Costa Rica (ITCR), the University of Costa Rica (UCR) and the National University (UNA)—, as well as in the National Nanotechnology Laboratory (2004) and the National Center for Biotechnology Innovation (2007), which form part of the public universities' institutional framework and are incorporated into the National Center for High Technology (CENTA).

MICITT is leading the process of drafting the National Bioeconomy Strategy and to this end it has established the Inter-ministerial Bioeconomy Committee, comprised of representatives of the Ministry of Agriculture and Livestock (MAG), the Ministry of the Economy, Industry and Trade (MEIC) and the Ministry of Environment and Energy (MINAE). The background to the preparation of the strategy is as follows: a) the country's process of adhesion to the OCDE, as a framework for articulating public policies and institutional efforts; b) the development of the National Decarbonization Plan, as an initiative to spearhead the full use of biomass and productive processes of the circular economy; c) Agenda 2030 for Sustainable Development; d) structural changes to move toward a knowledge-based bioeconomy and to make use of biodiversity resources; and e) public-private articulation, a process that has begun to occur in bioeconomy-related fields based on the creation of the Biological Sciences Cluster CR-Biomed.

Ecuador

EIn Ecuador, the development of the bioeconomy is approached as a mechanism for the sustainable use of biodiversity and as a strategy for resilience to climate change. The country is currently in the process of consolidating its regulatory, institutional and political framework, in order to establish the necessary conditions to develop a public policy for the bioeconomy. The aim is to create synergies between the different public, private, academic and social stakeholders.

Ecuador's legal framework, based on its Constitution (2008), outlines a scenario that favors the formulation and implementation of an institutional framework, together with the relevant public policies, associated with the bioeconomy. It also creates the conditions to enable the country to meet its commitments under various international agreements and to take advantage of its immense biodiversity in a context of sustainability, equity and equitable distribution. The Ministry of the Environment (MAE), as the institution responsible for native biodiversity management, has taken the initiative in leading efforts to develop the country's bioeconomy, for which purpose, and in the context of the Organic Code on the Environment, it established guidelines for bio-enterprises focused on the sustainable use of native biodiversity, through Ministerial Agreement 034.

Against this background, and in coordination with international cooperation, academia and the private and public sectors, certain strategic actions have been implemented in relation to the bioeconomy, including: a) the internal institutional reorganization of MAE and establishment of a multidisciplinary team to carry out the required work and create the conditions for the development of the bioeconomy; b) formation of a group of central government institutions, led by the MAE, to coordinate public policy on the bioeconomy and its links to sustainable biodiversity use; c) inclusion of the private sector as a key player in efforts to promote a dynamic bioeconomy; d) convergence of approaches, resources and experiences from

international cooperation; and e) progressive participation of academia as an essential stakeholder that promotes research and the incubation of businesses, as well as producer groups of the popular and sharing economy, which utilize and safeguard the country's native biodiversity. Together, these five strategic stakeholders constitute the initial nodes for the establishment of a bioeconomy network in Ecuador that will develop the public policy.

Finally, the Center for the Promotion and Facilitation of Bio-business (BioEmprende), was created as a platform for the coordination of stakeholders of the public, private and academic sectors, to enhance the environmental, technical and financial sustainability of bio-enterprises. This platform will serve to consolidate production experiences in the bioeconomy at local level, in the medium and long term, which can also be used as input for the development of a public policy on the bioeconomy.

Uruguay

A multisectoral process is currently under way to design the Sustainable Bioeconomy Strategy (EBS), as part of the "Uruguay 2050" National Development Strategy, under the responsibility of the Office of Planning and Budget (OPP), which is under the direct authority of the Office of the President.

The National Development Strategy has three main pillars: social development, the transformation of gender systems and the modernization of production. The bioeconomy, along with the digital economy, constitute the innovative core that is transforming production, through which the other more established production systems are interrelated, enhanced and modernized. The design of the Sustainable Bioeconomy Strategy (EBS) is based on several complementary public policies that are already being implemented, including: a) the Uruguay Agro-inteligente Platform for Production and Technological Innovation, implemented since 2010 by the Ministry of Agriculture, Livestock and Fisheries (MGAP); b) the energy policy implemented by the Ministry of Industry, Energy and Mining (MIEM), which has radically transformed energy sources used for electricity in favor of renewable energies; and c) other sectoral initiatives implemented by the National Agricultural Research Institute (INIA), the Uruguayan Antarctic Institute (IAU), Alcoholes del Uruguay (ALUR), a company of the ANCAP group (fuels) and the Institute for the Regulation and Control of Cannabis (IRCCA), etc. (Pittaluga 2008).

A second group of sectoral policies based on the EBS stems from the establishment of the Sectoral Councils (SCs) by the Production Cabinet, in 2010. These councils are made up of business and workers' representatives, as well as representatives of academia and technological institutes and the State, and their task is to formulate sectoral plans for the period up to 2020. In this context, 18 SCs are operating, all of which have achieved different goals in terms of stakeholder participation and the implementation of their plans. The Biotechnology SC is considered one of the most successful, since much of its plan has already been executed and it has also provided the basis for the Transforma Uruguay projects and for those of the National Innovation and Research Agency (ANII). The consolidation of the biotechnology sector is particularly important for the development of the bioeconomy (Pittaluga 2008).

The process of formulating the EBS has been led by the MGAP, which in turn has established an interinstitutional leadership group comprised of the OPP, Transforma Uruguay, MGAP, MIEM, the Ministry of Housing, Land Use and Environment (MVOT-MA) and the Ministry of Economy and Finance (MEF), given the cross-cutting and systemic nature of the bioeconomy. Since 2016, the German Ministry of Agriculture (BMEL) has provided advisory services for the implementation of this process; and, in 2017 Uruguay began to participate in the International Sustainable Bioeconomy Working Group (ISBWG), financed by the German government and coordinated by the FAO. The ISBWG includes 30 members: 14 countries (Germany, via the German Bioeconomy Council, Argentina, Brazil, Canada, China, Finland, France, Italy, Malaysia, Namibia, the Netherlands, South Africa, Uruguay and the United States); 2 regional government bodies and affiliated institutions (European Commission, with BBIJU, and the Nordic Council of Ministers); 2 NGOs (WWF and TSC); 3 private sector entities (BIC, WBCSD and DSM); 5 research institutions (FARA, SEI, CIAT, EMBRAPA and CREA); and 4 intergovernmental organizations (OECD, ECLAC, UNEP and FAO).

Finally, a third set of policies based on the EBS are the policies and plans to promote sustainable development (National Environmental Plan for Sustainable Development; National Climate Change Policy; National Water Plan; and the National Strategy for the Conservation and Sustainable Use of Biological Diversity), under the leadership of the MVOTMA and the National Climate Change Response System (SNRCC). All these conditions are necessary for the development of the bioeconomy in LAC.

4.4. Strategic topics for the development of the bioeconomy in LAC

The great majority of countries in the region have already prepared numerous public policies and institutions related to the development of the bioeconomy, in areas such as science, technology and innovation, climate change, sustainable agriculture, livestock and aquaculture, silviculture and biodiversity, biotechnology, bioenergy and use of residual biomass (Rodríguez et al. 2017, Rodríguez 2019). Therefore, the design of bioeconomy strategies should focus on the identification, coordination and alignment of those initiatives, and on the subsequent implementation of dialogue processes with the public and private sectors, academia and other relevant stakeholders, to develop any policies and strategies that are lacking, including the following:

1. **Creation of a framework of enabling policies,** especially in the areas of policy and regulations; science, technology and innovation; business promotion and valuation of biological resources; and, incentives to overcome barriers, generate demand and create conditions for access to and development of markets.

2. **Identify and resolve regulatory barriers** that hinder or limit the development of the region's bioeconomy, particularly the following:

   a) the complexity of national regulatory processes (for example, access to genetic resources);

   b) the absence of appropriate regulatory frameworks for advances in the biological sciences and technologies (for example, genetic editing -see Section 3.2.2);

   c) lack of capacity to comply with regulations in the destination markets for bioeconomy products, or ignorance of such requirements;

   d) incompatibility between regulations for conventional products and similar bioproducts;

   e) lack of harmonization of criteria for the classification of new products associated with the bioeconomy; and

   f) difficulties in the enforcement of existing regulations.

3. **Promote development of and access to markets** ((see Section 3.2.6) for products and services provided by the bioeconomy, both national and international, which may be grouped as follows:

   a) products that replace similar ones of fossil origin for which there are no well-developed markets, or whose access may be limited, either due to the difficulties of competing with mature fossil-based industries (for example, energy, plastics, agricultural inputs) or consumers' ignorance of the benefits of alternative bio-products; and

   b) new products and procedures that often encounter common market barriers associated with the lack of technical and scientific studies of various types, with logistical aspects and with matters related to certification, licenses, labelling and seals, and their associated costs, and the need to convince consumers that the products in question are innocuous and safe (Aramendis et al. 2018).

To overcome these barriers, it is necessary to make progress in:

   a) creating appropriate conditions so that consumers can make informed choices, e.g. in relation to pricing systems and standards to facilitate comparison of products;

   b) compensatory/promotional policies that balance the bioeconomy's competitiveness with that of "mature" markets based on fossil resources; and

   c) the use of public procurement mechanisms for bioeconomy products.

4. **Intensify investment in science and technology** to promote research, development and innovation processes. Biology-based processes require a new technological base, which in turn demands the reorganization of scientific research and development capabilities. Changes are also needed in production

levels and management, since development strategies based on biological resources are, in general, far more knowledge- intensive than those based on natural fossil resources.

Different types of knowledge are strategic instigators of these processes, but it is not only a matter of promoting biotechnology and engineering, but also of taking advantage of conventional approaches, particularly with regard to exploiting the full potential of the available biomass and the possibilities offered by the use of microorganisms in microbiological and biotechnological processes.

5. **Promote or develop economic and financial incentives,** with their own specificities, areas of focus and rules of access to enhance bioeconomy enterprises, including public funds in national development agencies, private national and regional funds, mixed public-private funds and international, regional and global cooperation funds (Aramendis et al. 2018)). It is essential to create a business environment that promotes and protects investment directed at new businesses and value chains, including risk capital, clear rules on intellectual property and the promotion of innovative initiatives (financial support, incubators, etc.).

6. **Develop legislation and capacity in intellectual property, together with a culture of knowledge protection.** For this it is crucial to improve communications and the integration between science and industry and acquire specialized knowledge for the management of different modalities for the protection of intellectual property and associated business models. Some important conditions include the following:

   a) guarantees for the protection of intellectual property in the national legislation, at the highest level possible, ideally in the national constitutions;

   b) establishment of modern mechanisms of protection that comply with international standards;

   c) a broad menu of protection mechanisms, including copyright, registered brands, industrial designs, utility models, patents and geographical indications;

   d) legal and political security; and

   e) harmonization of national intellectual property rights with provisions of the WTO Agreement on Aspects of Trade-related Intellectual Property Rights (TRIPS).

7. **Develop bio-entrepreneurship,** in startup businesses and SMEs, which are often pioneers and promoters of innovation in the bioeconomy. Therefore, it is important to improve their integration with global value chains and with the bioeconomy and help create a more level playing field, paying special attention to the needs of young innovators and those engaged in areas requiring the intensive application of advanced knowledge. To promote innovation and develop bio-entrepreneurship the following actions are considered important:

   a) develop innovative instruments to facilitate interaction between the new bio-economic enterprises (startups) and universities or research centers, and especially to promote bio- entrepreneurship among the youth;

   b) design financial and non-financial instruments (see Section 3.3.2) to help new bio-enterprises to access the bioeconomy markets and improve their capacity to respond and adapt to the speed of technological change;

   c) promote public-private and regional-multilateral cooperation to strengthen the national infrastructure needed to comply with requirements in the countries that import bioproducts, either in terms of physical infrastructure (for example, laboratories) or of quality assurance certificates; and

   d) foster a culture of enterprise that values freedom, creativity and innovation and that does not punish failure.

8. **Develop collaborative governance** in strategies for the bioeconomy, for which the following actions are essential (also see Section 3.3):

   a) establish some type of political agreement, either between public or private institutions, involving other

sectors of society, with the aim of building consensus on the notion that such agreement is a State decision, and not the policy of a specific government;

b) define a permanent coordination mechanism for the formulation and management of the bioeconomy strategy; establish an advisory group with national or international experts; create working and consensus-building groups (with academia, government and business), focusing on the identification of bottlenecks and the search for solutions; and

c) create spaces for information and dialogue with civil society to raise awareness and educate people about the potential of the bioeconomy.

9. **Create incentives for public-private cooperation,** so that the private business sector will appropriate the objectives implicit in the bioeconomy and redirect its investments accordingly. Many of these new areas of knowledge, technologies and products are still within the academic world, and require development processes, which increase the risk in new activities and enterprises. This point should be recognized in financing or co-investment schemes. It is also necessary to systematize information on financing mechanisms for innovation and make this information available to interested and potential bio-innovators.

   Public-private and private-private cooperation is essential to assure consumers that bioproducts are safe and sustainable, and to create demand and markets for these. It is also important to use existing bodies, such as the chambers of commerce and industry, associations and technology transfer offices, to promote the creation of cooperation networks, share best business practices and, in general, educate and inform their communities about the opportunities offered by the bioeconomy, as well as potential risks.

10. **Implement communication, dialogue and awareness-raising strategies** about the economic, social and environmental potential and benefits of the bioeconomy. These communication mechanisms should be based on sound knowledge of the many benefits and possible risks of the bioeconomy and should involve all relevant levels:

    a) public policymakers, communities and parties interested in sustainable development issues, because of the response that a sustainable bioeconomy can provide to the aspirations and needs of society, given its links with many of the SDGs;

    b) the business community, because of the economic opportunities and benefits derived from the development of new products, production processes, businesses and value chains, on the one hand, to satisfy growing demand for more environment-friendly products and forms of production and, on the other, to create new jobs of quality and new markets; and

    c) citizens, to generate confidence in the safety of consuming bioeconomy products and awareness of the benefits of obtaining products with a lower carbon footprint.

11. **Monitor the progress and assess the impact of policies and strategies** that support the development of the bioeconomy, especially because its multidisciplinary and intersectoral nature implies a highly complex implementation process and effective public policies. Moreover, it is indispensable to appraise the economic value and importance of the bioeconomy, for which there is no universally accepted methodological framework. This challenge is even greater because the bioeconomy generates new products, processes, sectors and value chains, for which the current statistical systems have not yet developed classification systems (for example, tariff headings for the classification of exports). Moreover, there is no monitoring framework to cover the three areas of sustainability, i.e. economic indicators as well as environmental and social indicators.

12. **Promote international cooperation,** as an important and essential tool, not only because of its contributions to addressing the global challenges of the coming years, but also because of the opportunities and challenges shared by many countries of the region. In addition, resolving obstacles and developing the required technological base includes major public goods components, offering significant benefits derived from joint work and mutual learning.

    Indeed, a major reason that the region has adopted the bioeconomy concept as an option for a more sustainable

and equitable development, responds in great measure to the implementation, from 2012 onwards, of a series of cooperation projects in the context of the Framework Program 7 (FP7) and Horizonte 2020 (H2020) of the European Commission, with the participation of European and LAC countries, in which opportunities and options for the development of the region's bioeconomy were analyzed and discussed (Hodson 2015, Hodson of Jaramillo et al. 2019).

The importance of international cooperation in the development of the region's bioeconomy was also discussed recently at the First Latin American Symposium on the Bioeconomy, "Rethinking Development: New Opportunities for Latin America and the Caribbean" (Bioeconomia Argentina 2017), in which the participants agreed to create a Latin American Bioeconomy network. The aim is to exchange experiences and work together on the development of a vision for the Latin American bioeconomy, educate and train human resources, develop and transfer strategic technologies and methodologies to measure, monitor and assess the progress achieved by the sectors involved, and support the design of policies and standards for the sector.

Visit the website at **www.agrirural.org** to access the full report and other information resources that may be of interest to users: historic reports, technical bulletins, executive summaries, infographics, videos, *inter alia*.

UNITED NATIONS
ECLAC

Economic Commission for Latin America and the Caribbean
Headquartes: Av. Dag Hammarskjöld 3477, Vitacura, Santiago de Chile
Telephone: (56-2) 2271-2000 • 2210-2000
Fax: (56-2) 2208-0252
PO Box: Casilla 179-D, Santiago de Chile
Postcode: 7630412
E-mail: dpisantiago@un.org
Website: www.cepal.org

Food and Agriculture Organization of the United Nations

Food and Agriculture Organization of the United Nations
Regional Office for Latin America and the Caribbean
Av. Dag Hammarskjöld 3441, Vitacura
Santiago, Chile
Telephone: (56-2) 2923-2100
E-mail: FAO-RLC@fao.org
Website: www.fao.org/americas

IICA

Inter-American Institute for Cooperation on Agriculture
Headquarters
PO Box: 55-2200 San José, Vázquez de Coronado
Telephone: (506) 2216-0222
Fax: (506) 2216-0233
E-mail:iicahq@iica.int
Website: www.iica.int