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AGRICULTURE SECTOR FRAMEWORK DOCUMENT

ENVIRONMENT, RURAL DEVELOPMENT, AND RISK MANAGEMENT DIVISION

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CONTENTS

ABBREVIATIONS

Agtech	Agricultural technologies
CSA	Climate-smart agriculture
FAO	Food and Agriculture Organization of the United Nations
FMD	Foot-and-mouth disease
GCI	Global Competitiveness Index
GDP	Gross domestic product
GHG	Greenhouse gas
IDB Invest	Private-sector investment arm of the IDB Group (formerly Inter-American Investment Corporation (IIC))
IDB Lab	Innovation laboratory of the IDB Group (formerly Multilateral Investment Fund (MIF))
IPM	Integrated pest management
IRR	Internal rate of return
LAC	Latin America and the Caribbean
masl	Meters above sea level
MIRR	Modified internal rate of return
MPA	Marine protected area
OECD	Organisation for Economic Co-operation and Development
OVE	Office of Evaluation and Oversight
PES	Payment for environmental services
RBM	Rights-based management
R&D	Research and development
R&D&I	Research, development, and innovation
SDG	Sustainable Development Goal
SFD	Sector Framework Document
TFP	Total factor productivity
WWF	World Wildlife Fund

EXECUTIVE SUMMARY

Agriculture[1] plays a critical role in the future of the planet and the welfare of its inhabitants. Although a country's Agriculture sector becomes relatively smaller as the economy expands and diversifies (which may continue to happen in the countries of Latin America and the Caribbean (LAC)), population growth and climate change projections, coupled with the decline of natural resources and the high prevalence of malnutrition and diet-related diseases, mean that the sector will be called upon to deal with a series of critical challenges for the future of humankind and the planet. LAC is economically, socially, and environmentally integrated into the rest of the world. Thus, Agriculture in the region shares the sector's challenges at the global level, albeit with differences in size and subject to specific characteristics. Addressing these challenges requires taking action not only on primary production but possibly on all components of the food systems, from the farm to the point of sale.

The first challenge is to boost production to feed a growing population. It is estimated that the world population in 2050 will reach 9.8 billion, with 780 million in LAC (representing an increase of 29% and 20%, respectively, with respect to the figures for 2017). The region will need to produce more food for its population and, being the largest net food exporting region, for the rest of the world as well. However, this task will be made difficult by three factors: (i) the proportion of the population engaged in Agriculture will probably be smaller; (ii) climate change will adversely affect agricultural productivity; and (iii) biodiversity, necessary for food and Agriculture, is in decline. In view of this, **the Agriculture sector will need to boost its productivity and reduce its vulnerability**.

The agricultural productivity of the region has risen at a good pace since 2000 (especially until 2011), but the gap with respect to developed countries continues to be wide. This is particularly true if Brazil, Argentina, and Mexico, which together account for more than 80% of the increase, are not considered in the calculation. To boost productivity, the region needs to make substantial investments to improve the basic conditions that allow the sector to develop, namely irrigation, transportation, and telecommunications infrastructure, as well as innovation, animal and plant health, and information and statistics services, among others. Since many of these items are public or semipublic goods,[2] the State plays an essential role in providing them, and the empirical evidence shows that investing in them generates the greatest benefits in terms of productivity and economic growth. In addition, they will be needed to enable widespread adoption and good use of the new digital and biological technologies, which promise to deliver great production and environmental advantages.

The vulnerability of Agriculture in LAC stems from several sources. One of these is extreme climate events, to which the region is particularly exposed and which are expected to become increasingly frequent and intense due to climate change. In addition, climate change will cause some areas to no longer be suitable for agriculture, will reduce marine population through ocean acidification, and will facilitate the propagation of pests and diseases that affect plant and animal species used in agricultural production. Lastly, market volatility is also a risk factor affecting the yield of agricultural activities. Thus, the

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1 In this Sector Framework Document, Agriculture (capitalized) is understood in a broad sense as including agriculture (crop farming), livestock farming, fishing, and forestry.

2 A public good is a good the benefits of which: (i) are not diminished for any individual when enjoyed by another individual (principle of non-rivalry); and (ii) cannot easily be physically denied to an individual (principle of non-excludability).

Agriculture sector needs to adapt to climate change and become more resilient to climate-related and economic shocks. Climate-smart agriculture (CSA), agroecological practices, various new technologies—such as drought-resistant varieties—, and agricultural insurance are essential tools for achieving this goal.

The second challenge is to reduce the impact of Agriculture on the environment. Agriculture and land-use change (which is primarily driven by Agriculture) account for 42% of greenhouse gas (GHG) emissions in LAC (3.5% of global GHG emissions). The region is responsible for 47% of GHG emissions resulting from deforestation. More than 800,000 km^2 of Amazonian jungle (an area equivalent to 90% of Venezuela's landmass) has been deforested for use in crop and livestock farming, and this development may be close to irreversibly altering the rainfall patterns of the region south of the Amazon. While the region has an abundance of water resources, their spatial and temporal distribution often fails to match the demand for them. This has led to a substantial increase in irrigation (mainly nontechnified, making inefficient use of water), creating shortages in many watersheds as well as aquifer overexploitation and salinization. The enormous biodiversity characteristic of LAC is fast declining. Loss of habitat (due to land-use change, itself primarily a result of Agriculture) and overexploitation are the main reasons why the region has the highest total number of threatened plants, mammals, fish, and birds.

Faced with this situation, Agriculture needs to implement fundamental changes in the form of widespread adoption of cutting-edge technologies and changes in agricultural practices. Precision agriculture and climate-smart and agroecological farming practices are promising areas in this regard. Payment for environmental services (PES) can become an effective mechanism for encouraging the adoption of these practices but needs to be carefully designed. Reducing deforestation is of prime importance; thus, proper management of forest and other common resources is essential. This requires establishing solid governance structures, but the evidence as to which policies are most effective is still not very robust. Lastly, food production consistent with healthier diets is an important factor for reducing GHG emissions in the sector.

The third challenge consists of reducing poverty and inequality in the sector. As of 2016, 48.6% of the rural population of the region lived in poverty and 40% in extreme poverty, significantly more than for the urban population—26.8% and 7.2%, respectively. Besides being characterized by low income levels, rural areas significantly lag in the coverage of basic services, education, and health. The low rural standards of living are the outcome of rural-urban migration, which can lead to demographic aging in rural areas. All this affects the Agriculture sector, hindering generational renewal, resulting in insufficient adoption of technology, and perpetuating poverty within the sector. In addition to poverty, the sector is marked by significant inequalities. Women account for a mere 20% of agricultural jobs, are paid substantially less than men, and tend to have lower-quality, informal, or temporary jobs. Moreover, they manage a very small fraction of the farms (and that fraction tends to include smaller farms, with lower-quality land) and own less land than men. Lastly, there is a high degree of concentration throughout the value chains (from markets for inputs to export markets), which points to limited economic competition and may point to the existence of economic inefficiencies.

Addressing poverty in agricultural producers requires boosting their productivity and reducing their vulnerability. In this regard, the above-described policies and actions can be very useful if they are targeted to producers that face shortcomings in production infrastructure and public services. In addition, policies aimed to encourage the adoption of technologies can be effective in raising productivity and reducing poverty. However, in the case of subsistence Agriculture, a solution for poverty solely based on Agriculture is not viable; what is needed instead is to implement programs that combine production-related and social characteristics.

The fourth challenge for the sector is to provide the necessary components of a healthy diet. This means producing a sufficient amount of safe, good-quality food with the variety required for a nutritious diet. The world population faces a serious malnutrition problem, partly due to poor diets. These are considered the main risk factor for some noncommunicable diseases (such as type-2 diabetes, coronary heart disease, and various types of cancer) and are estimated to have been responsible for 22% of adult deaths in 2017. In LAC, the population does not eat a healthy diet and there is a high rate of diet-related diseases. Part of the problem is that food systems are significantly deficient in terms of delivering varied, nutritional, and safe food to the most vulnerable population segments. There are various types of action that can be implemented in the food systems to help resolve this situation (the reader may consult the Food Security Sector Framework Document, which contains a review of the related empirical evidence).

The challenges faced by the Agricultural sector, while formidable, at the same time create an opportunity. This is an essential sector, and advancing its development sustainably and inclusively will result in major social, economic, and environmental benefits. To achieve this, the IDB Group will support the countries in the region through five lines of action:

1. Foster investments that help to boost Agricultural productivity consistent with sustainable management of natural resources.
2. Foster sustainable Agriculture that reduces and offsets its impact on the environment.
3. Develop and implement instruments that sustainably boost the income of small agricultural producers.
4. Support production of the foods needed for a healthy diet.
5. Knowledge agenda.

I. The Agriculture Sector Framework Document in the Context of Current Regulations, the Institutional Strategy, and International Agreements

1.1 The Agriculture Sector Framework Document is aimed at guiding the work of the IDB Group with the countries of Latin America and the Caribbean (LAC) in the Agriculture sector. For purposes of this Sector Framework Document (SFD), unless otherwise indicated, "Agriculture sector" or "Agriculture" (capitalized) refer to the economic sector that encompasses agriculture (in lower case to refer to crop farming), livestock farming, fishing (including aquaculture), and forestry, and the adjective "agricultural" means belonging or related to the Agriculture sector.

1.2 This SFD considers both the sector's primary production and the food systems, understood as the set of "all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation, and consumption of food, and the outputs of these activities, including socioeconomic and environmental outcomes" (HLPE, 2014). In other words, the Agriculture SFD takes into account not only the production of agricultural products and those who carry it out, but also, although to a lesser extent, the various areas and participants needed to ensure that consumers have physical and economic access at all times to safe and nutritious food in sufficient quantity to lead an active and healthy life.

1.3 The SFD also underscores the Agriculture sector's impact on the environment (loss of biodiversity, water and soil pollution, and greenhouse gas (GHG) emissions) and the urgent need to find ways of substantially reducing this impact while at the same time continuing to produce food in amounts that will be needed by an expanded population.

1.4 This document has been prepared in accordance with document GN-2670-5, "Strategies, Policies, Sector Frameworks, and Guidelines at the IDB," which provides for creating the SFDs. In line with the provisions of the aforementioned document, this SFD replaces the Agriculture and Natural Resource Management SFD (document 2709-5), addressing natural resource issues only when related to Agriculture. Natural resource issues not related to agriculture will be addressed in the Environment and Natural Resources Management SFD.

1.5 This SFD is consistent with the Update to the Institutional Strategy 2010-2020 (document AB-3008), which identifies social exclusion, inequality, and low productivity and innovation levels as development challenges for the region. It is related to the Strategy on Social Policy for Equity and Productivity (document GN-2588-4), which seeks to make the Bank more efficient in promoting social policies aimed at boosting equality and productivity in the region. In addition, it is related to the following SFDs: Climate Change (IDB, 2018a); Environment and Biodiversity (IDB, 2018e); Social Protection and Poverty (IDB, 2017a); Health and Nutrition (IDB, 2016b); Food Security (IDB, 2018c); Transportation (IDB, 2016c); Energy (IDB, 2018d); Water and Sanitation (IDB, 2017d); Support to SMEs and Financial Access/Supervision (IDB, 2017b); Innovation, Science, and Technology (IDB, 2017c); and Integration and Trade (IDB, 2019).

1.6 Furthermore, the Agriculture SFD dovetails with the following Sustainable Development Goals (SDGs): SDG1: end poverty in all its forms everywhere, since poverty in rural areas is closely related to Agriculture sector revenues; SDG2: end hunger, achieve food security and improved nutrition, and promote sustainable agriculture, since the Agriculture sector is responsible for food production; SDG3: ensure healthy lives and promote wellbeing for all at all ages, since the sector is the main source of income for, and a key to the welfare of, many rural families, in addition to being essential for the diet and nutrition of the population; SDG5: achieve gender equality and empower all women and girls, since many of the supported actions are aimed at improving gender equality in the sector; SDG6: ensure the availability and sustainable management of water and sanitation for all, since the Agriculture sector is the largest consumer of water; SDG8: promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all, since development of the sector directly contributes to economic growth and employment; SDG10: reduce inequality within and among countries, since the Agriculture sector provides an opportunity to improve the living conditions of agricultural producers and reduce inequality; SDG12: ensure sustainable consumption and production patterns, since the sector needs to transition to sustainable exploitation of natural resources; SDG13: take urgent action to combat climate change and its impacts, since the sector is a significant emitter of greenhouse gases while also playing an important role in carbon capture; SDG14: conserve and sustainably use the oceans, seas, and marine resources for sustainable development, since the Agriculture sector includes fishing; SDG15: sustainably manage forests, combat desertification, and halt and reverse land degradation, and halt biodiversity loss, since the Agriculture sector includes forestry, in addition to being directly related to land-use change.

1.7 The rest of this document is structured as follows: Section II briefly describes the Agriculture sector and the main development challenges it faces. Section III presents evidence on the effectiveness of policies and programs in addressing the sector's development challenges identified in Section II. Section IV summarizes the lessons learned by the IDB Group. Lastly, Section V lists the lines of action that will serve as a basis for the IDB Group as it supports the region in addressing the challenges identified in Section II.

II. MAIN CHALLENGES FOR THE AGRICULTURE SECTOR IN THE REGION

2.1 Agriculture is an essential component of any society. Not only is it an economic sector that generates revenue and jobs, but it is the ultimate source of food and a fundamental cultural element. Being a predominantly rural activity, and thus subject to climate and seasonality, Agriculture is a determinant of the rural way of life and, being at the origin of practically all foods,[3] it is closely linked to the health of the population and to local gastronomic traditions.

2.2 As a country's economy grows and diversifies, the Agriculture sector becomes relatively smaller. The value of the sector's production and the number of people it employs may rise in absolute terms, but the size of the sector diminishes as a percentage of the economy (see Figure 1).[4] While this phenomenon is observed in virtually all countries and is therefore expected to become increasingly entrenched

[3] Hunting and gathering are additional sources of food and are important for some original peoples.

[4] All figures are set out in the Annex to this document.

in the countries of Latin America and the Caribbean (LAC), this does not mean that the Agriculture sector is destined to have a position of marginal importance. On the contrary, in view of the population growth and climate change projections, and considering the decline in natural resources and the high prevalence of malnutrition and diet-related diseases, the Agriculture sector is called upon to play a critical role in the future of the planet and the welfare of humankind.

2.3 The LAC region is economically, socially, and environmentally integrated into the rest of the world. Its food systems are a part of the global food systems and share the challenges facing the Agriculture sector at a global level, even if there are differences in terms of size and specific characteristics, as described below. These challenges, while formidable, at the same time create an opportunity. Agriculture is an essential sector and advancing its development sustainably and inclusively will yield significant social, economic, and environmental benefits.

A. Challenge 1. Boost production

2.4 **Food production will have to rise substantially to address the food needs of a growing population.** It is estimated that, in 2050, the world population (at 9.8 billion) will be 29% larger than in 2017 and the LAC population (at 780 million) will be 20% larger (UN, 2017). The most broadly accepted estimates indicate that world agricultural production will need to expand by 50% (UNEP, 2019). This is a major challenge for at least three reasons. The first is that the proportion of the population engaged in Agriculture will probably be smaller (UN, 2018), requiring an increase in labor productivity in the sector. The second reason is that climate change will have an adverse effect on agricultural production (due to increased climate variability, including more frequent extreme climate events, as well as to rising temperature, changing rainfall patterns, rising sea levels, and more extensive damage from pests and diseases (Campbell et al., 2016; FAO, 2018d; Mall et al., 2017).[5] The third reason is that the biodiversity needed for food and Agriculture[6] is in decline, jeopardizing the future of agricultural production (FAO, 2019c).

2.5 **LAC accounts for just under 10% of global agricultural production but is the world's largest net food exporting region.** Between 2010 and 2016, LAC generated 9% of the world's gross agricultural production, less than Europe, Asia, and even North America. Nevertheless, it was the largest agricultural exporting region, with 29% of global exports (44% of positive net exports; see Figure 2), evidencing its key role in feeding the world population.

2.6 **The foregoing are aggregate figures and therefore conceal the extensive disparities within LAC.** For example, between 2010 and 2016, 71% of the region's production originated in just three countries (Brazil, Mexico, and Argentina), and net exports were even more concentrated (Brazil and Argentina accounted for 80% of positive net exports). Over the same period, 11 of the IDB borrowing member countries, including Mexico, were net agricultural importers (see Figure 3). It is worth

[5] While agricultural production may benefit from climate change in some parts of the world (such as Canada and the Russian Federation), the net global effect is expected to be negative (FAO, 2018d).

[6] The biodiversity needed for food and Agriculture refers to all the plant and animal species—wild and domesticated—that provide food, feed, fuel, and fiber, as well as the organisms that support agricultural production through ecosystem services (FAO, 2019c).

noting, however, that agricultural production is important even for the latter group of countries, accounting on average for about 55% of domestic consumption (almost 65% if the Caribbean countries are not included).[7]

2.7 To help supply the growing national and international markets, **the Agriculture sector in the region needs to boost its productivity and reduce its vulnerability, particularly among its small-scale producers.**

1. Boost productivity

2.8 **Productivity can rise for two reasons: technological changes or efficiency gains.** The former has to do with innovation, the implementation of "new" ways of producing (new at least for those who implement them for the first time), whether through the use of new machinery, equipment, inputs, or techniques. The latter refers to a more precise, less wasteful use of inputs and factors of production, including land, water, labor, seeds, and agrochemicals.[8]

2.9 **Between 2003 and 2016, agricultural productivity in LAC grew significantly, although the pace has slowed since 2012.** Between 2003 and 2011, the total factor productivity (TFP) of the Agriculture sector in the region grew at an annual pace of 2.2%. Between 2012 and 2016 (the last year for which data are available), the annual growth rate of TFP fell to 1.3% as a result of the economic slowdown in the region and international conditions such as the end of the boom in commodity prices and the slow recovery of the global economy following the international financial crisis. Even so, these TFP growth rates are not low if compared to historical trends (Nin-Pratt, 2019). Furthermore, they are slightly higher than the global average[9] and occur in a context of low TFP growth for the economy of the region as a whole,[10] showing that Agriculture can make a significant contribution to economic growth.

2.10 **The growth of TFP was primarily due to technological change rather than to improvements in efficiency.** In other words, the adoption of new technologies allowed the region to expand the potential output obtainable for each unit of input. However, efficiency in the use of inputs grew at a much more modest rate, increasing by 5% between 2000 and 2016, compared to a 30% growth rate for technological change over the same period (see Figure 4).

2.11 **The rise in regional TFP conceals significant disparities across countries in terms of productivity growth, as well as a significant gap with respect to more developed countries.** The above-described growth narrowed the productivity gap between LAC and the OECD countries from 67% to 59%. This was mainly due to TFP growth in Brazil, Argentina, and Mexico, which respectively accounted for 54%, 18.3%, and 9.6% of the total for the region. At the same time, other countries had

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7 Authors' own calculations based on data from FAOSTAT, 2019.

8 Technological changes and efficiency gains may take place during or following primary production (for example, during storage).

9 According to U.S. Department of Agriculture Economic Research Service (USDA ERS) calculations, agricultural TFP in LAC grew by 5.7% between 2011 and 2015 (the most recent date in those calculations), while global TFP growth was 4.7%.

10 According to a recent study, TFP growth in the LAC economy as a whole averaged 0.38% per year between 2005 and 2015 (Rabanal, 2017).

annual average TFP growth rates of less than 1% (Bolivia, El Salvador, and Venezuela) or in negative territory (Trinidad and Tobago (-1.6%), Belize (-0.9%), and Uruguay (-0.2%)) (Nin-Pratt, 2019).

2.12 **The public sector plays a vital role in boosting agricultural productivity.** Despite accounting for a relatively small fraction of total investment in the sector, especially in LAC (see Figure 5), public investment performs two important functions: resolving economic inefficiencies created by market failures and reducing undesirable inequality or poverty levels (Mogues et al., 2012). Markets tend to fail in providing public or semipublic goods[11] (such as agricultural health infrastructure and services, and research and development). Thus, State intervention is essential for a proper provision of these goods and the resulting rise in productivity. The following paragraphs describe the shortcomings faced by the region in terms of public or semipublic goods that affect agricultural productivity the most. The high level of heterogeneity across the region makes it impossible to provide an overall prioritization of these shortcomings, since the challenges the countries face (and even different regions within those countries) vary significantly.

2.13 **Agricultural statistics and information play a critical role and generate great benefits by enabling an evidence-based investment decision-making process** (Gardner, 2004). This is crucial in allowing public investment to be effective and lead to increased productivity and reduced vulnerability, among other things. Thus, it is important to have periodically updated information on the Agriculture sector, including censuses and probabilistic surveys (FAO, 2017c). For this reason, in 2010 the United National Statistical Commission, the World Bank, and the FAO formulated a global strategy to improve agricultural and rural statistics (World Bank et al., 2010). The use of this strategy in a country includes an initial assessment of the national information and statistical systems. The 16 LAC countries for which information is available are vastly different from one another in terms of their systems: while in some countries these systems are classified as strong, others have significant weaknesses in the four dimensions examined (see Figure 6).

2.14 **Irrigation infrastructure**. Irrigation is one of the major determinants of the level and stability of agricultural productivity, as well as an important measurement of climate change adaptation. A recent estimate shows that LAC has 16% of the world's agricultural land but only 6% of the irrigated land (Meier et al., 2018). However, since crops, precipitation levels, and soil conditions are different in LAC from those in other regions, the irrigation needs are also different. Even so, an indicator that considers these factors suggests that the irrigation deficit in LAC is lower than in Asia and southern Europe but higher than in other regions of the world (see Figure 7).

2.15 **Transportation infrastructure**. Transportation infrastructure in rural areas is essential for agricultural productivity and poverty reduction (IDB, 2016c), facilitating access to inputs on a timely basis and at a lower cost, preventing losses during transportation, and improving access to domestic and international markets. In LAC, there are significant deficits in rural transportation infrastructure, primarily in terms

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11 According to the economic literature, public goods are those that have the following two characteristics: they are non-rivalrous (i.e., the benefit obtained by one consumer of the good does not diminish the benefit obtained by the rest of the consumers) and they are non-excludable (i.e., it is very difficult to prevent an individual from enjoying the benefits of the good). These two characteristics are a theoretical construct and occur to a greater or lesser extent in real life, giving rise to so-called semipublic goods.

of quality. Road density is at medium levels in the region's countries, in some cases comparable to those of other countries with a smaller land area (see Figure 8). However, in terms of perceived quality of roads, the 20 LAC countries included in the World Economic Forum's 2017-2018 Global Competitiveness Index (GCI) fall in the middle and low portions of the 137-country distribution (see Figure 9).

2.16 **Power infrastructure**. Lack of access to a stable source of electricity affects the productivity of food systems and their ability to integrate into international markets. In 2017, rural electrification in LAC averaged about 88% and only some countries had achieved a rural electricity coverage of more than 95%, while others showed significant lags (see Figure 10). Furthermore, the quality of the electricity supply is deficient. In the GCI, LAC countries have an average score of 4.31 (out of a possible 7), compared to 4.77 for the rest of the world.

2.17 **Connectivity and digital technologies**. Agriculture is increasingly based on high technology and knowledge. Specifically, digital technologies[12] have expanded the information base for the sector as well as the ability to transmit and process this information (World Bank, 2016), thus changing every segment of the value chain (Rodrigues & Rodriguez, 2013; World Bank, 2016) and providing a great opportunity to boost yields, reduce the use of inputs, and lessen the environmental impact, among other possibilities. Adoption of agtechs[13] in LAC is limited, lower even than in Asia and Sub-Saharan Africa (see Figure 11). In addition, a recent report indicates that, due to lack of coverage, less than 5% of rural households have internet access (Trendov et al., 2019).

2.18 **Animal and plant health and food safety services.** Animal and plant health and food safety services are aimed at preventing pest outbreaks or harmful substances in foods, whether domestic or foreign in origin, affecting agricultural production, international trade, or consumer health. For this reason, many of the services they provided (such as epidemiological surveillance) have public-good characteristics. While animal and plant health and food safety services exist in all LAC countries, they are highly heterogeneous in terms of quality, as shown by the number of health-related rejections of agricultural products exported to the United States by countries in the region (see Figure 12).

2.19 **Research and development (R&D).** Strengthening agricultural innovation by means of R&D processes is one of the most powerful and long-lasting solutions for promoting agricultural growth and reducing poverty (Fan, 2008). New digital technologies and biotechnology, particularly CRISPR, have disruptive potential for boosting agricultural productivity; thus, it is imperative to encourage their

[12] A recent study divided agricultural digital technologies into five categories: (i) mobile devices and social media; (ii) precision agriculture and remote detection technologies (including the internet of things, variable input use, drones, and satellite imagery); (iii) big data, the cloud, information analysis, and cybersecurity; (iv) integration and coordination (including blockchain); and (v) smart systems (e.g., artificial intelligence) (Trendov et al., 2019).

[13] There is no single definition of agtech. As an abbreviation of agriculture technology, the term can encompass technologies of all types, including non-digital (such as gene editing). However, there are those who maintain that the term refers to digital technologies (see, for example https://www.weeklytimesnow.com.au/agribusiness/decisionag/agtech-what-the-umbrella-term-really-means/news-story/1779963d380acb1780e85fcd4637a28d). In this specific case, which involves mobile agtechs, the term does in fact refer to digital technologies.

development in the region through mechanisms that coordinate public- and private-sector efforts. Unfortunately, most of the LAC countries invest little in agricultural R&D. Brazil, Mexico, and Argentina account for 78% of this investment; together with Chile and Uruguay, they are the countries that invest the most[14] as a percentage of agricultural GDP (1.44% on average between 2004 and 2013; see Figure 13), yet even in these cases (excluding Chile and Mexico), the amount invested is lower than the 1.8% of agricultural GDP invested by OECD countries.[15] In addition, national institutes for agricultural research and development tend to have limited ties to the private sector for innovation promotion purposes. For example, a recent mapping of agtech enterprises in LAC carried out by IDB Lab found that most of them are purely private businesses and originate in Brazil or Argentina (see Figure 14). Similarly, the regulatory frameworks also pose a challenge since they do not always facilitate the development of leading-edge technologies (such as developments in biotechnology)[16] and are not harmonized with the frameworks in other countries within and outside the region.

2.20 **Agricultural technology transfer and extension services.** These services, which may be provided on a public, public-private, or private basis, are a key factor in accelerating agricultural innovation. The available information for the region shows that publicly provided agricultural technology transfer and extension services serve a much larger number of producers than private or public-private services. For example, in Paraguay, 112,000 producers are served through public-sector financing versus 5,800 through private-sector financing; in Chile, the figures are 105,300 versus 31,000; in Argentina, 681,400 versus 115,600; and in Ecuador, 198,000 versus 11,700. Annual investment in agricultural technology transfer and extension services per producer ranges from US$200 (Colombia and Paraguay) to more than US$1,000 (Argentina, Chile, and Peru). In most of the region's countries there is a weak connection between rural extension and research and educational systems (Argentina's INTA being an exception) (FAO & IDB, 2016).

2.21 **Land administration systems.** Establishing and maintaining property rights is a public good that, among other things, can foster investment and boost productivity. The reason for this is that it reduces the risk of losing the land through invasion or usurpation, frees up resources used to defend the land, enables more productive persons to acquire land, and makes it possible to use land as collateral to obtain loans (Besley & Ghatak, 2010). In LAC, despite efforts expended to date, a significant portion of rural areas and agricultural producers lack, or have outdated, property titles. While systematized information in this regard is not yet available, some examples can illustrate the situation. In 2012, 44.7% of agricultural producers in Peru lacked property titles (INEI & MINAGRI, 2013); by 2014, tenure regularization processes had either not been completed or had not been started in 48% of the

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[14] Trinidad and Tobago and Barbados invest a large proportion of their agricultural gross domestic product (GDP) (respectively 8.67% and 2.09% from 2007 to 2012), but this is due to the small scale of their economies. In absolute terms, their investment is considered far lower than is needed.

[15] The authors' own calculations using Agricultural Science and Technology Indicators (ASTI) data for 2019 (available at http://www.asti.cgiar.org/) and OECD.Stat data (https://stats.oecd.org/) (in both cases checked in June 2019).

[16] Lactose-free milk and non-oxidizing potato, recently developed by Argentina's Instituto Nacional de Tecnología Agropecuaria [National Agricultural Technology Institute] (INTA) using gene editing technology, are two examples.

agricultural area in Bolivia (Colque et al., 2016); as of the mid-2000s, more than 54% of the farms (and more than 60% of the small producers) in Paraguay lacked property titles (CAN, 2008). In addition, many land administration systems in LAC face significant challenges, such as incomplete or inaccurate information on land and limited sharing of this information between cadastral and property registration institutions, as well as limited institutional capacity to perform the four basic functions of a modern land administration system (tenure management, appraisal, use planning, and land development).

2.22 **Access to finance.** Limited access to financial services is one of the major development constraints faced by the Agriculture sector in LAC. Relative to other regions, the rural population in LAC has a medium level of banking use (percentage of individuals aged 15 or older with an account at a financial institution) but a low level of savings at financial institutions and low use of loans, whether formal or informal (see Figure 15). Within the region, various indicators of access to finance show great disparities across countries (see Figure 16). The provision of credit in rural areas is limited, due in part to the risks and cycles inherent in Agriculture but also to the difficulty of obtaining reliable information on the repayment capacity of borrowers and the dearth of physical assets that may be used as collateral (Gallardo et al., 2006). In some cases, agricultural insurance policies may be used as an alternative to collateral to facilitate credit access (Meyer et al., 2017). However, as described below, the use of agricultural insurance is also very limited in the region.

2.23 **Social capital and agricultural producer associations.** Another way in which public intervention can help to boost productivity and integrate producers into global value chains is by supporting the creation of associations. In LAC, social capital often becomes a decisive factor in agricultural production, improved access to factors of production and credit, adoption of technologies, and greater participation in national and international agricultural value chains (Abay et al., 2018; Ainembabazi et al., 2016; Okten & Osili, 2004; Salazar & Winters, 2012; Verhofstadt & Maertens, 2014). The latter occurs, in part, through scaling up. When producers partner with one another they gain greater market power and increased capacity to access wholesale markets. This, in turn, can enable them to hire specialized services (such as administration services) and obtain more sophisticated financial products (such as derivatives). A recent analysis argues that, in LAC, it is not enough for agricultural producers to raise their productivity to achieve higher revenues; rather, they need to strengthen their links with other segments of the value chain and with economic agents and institutions that can enable them to compete in national and international markets (Ardila et al., 2019). At the same time, and despite being a positive economic result, strengthening small-scale producers' market share can produce tension with the economic interests of bigger players in the value chains, whose market power could be reduced. However, systematized information in this regard is still limited.

2. Reduce production-related vulnerability and risks

2.24 **To meet the challenge of boosting production, food systems in LAC also need to adapt their production capacity to the new and changing climate conditions, including the risks of extreme climate events.** According to various studies, without changes to the current production systems, climate change will bring about reduced agricultural productivity[17] (ECLAC, 2014; ECLAC et al., 2013; Descheemaeker et al., 2018; Fernandes et al., 2012; Hristov et al., 2018; Myers et al., 2017), diminished water availability, supply chain disruptions, and alterations in storage conditions, as well as damage to infrastructure and inaccessibility of public services (FAO & PAHO, 2017). By the same token, the volume and patterns of food trade will be altered (Ahammad et al., 2015).

2.25 **Productivity losses will in part be due to a proliferation of certain plant diseases** (Evans et al., 2008; Ghini et al., 2011; Huot et al., 2017), which will also affect production quality (Chakraborty & Newton, 2011; Ovalle-Rivera et al., 2015). In Central America, increases in temperature may have contributed to the coffee rust epidemic that caused coffee harvest to decline by up to 25% in the 2012-2013 cycle (ECLAC, 2014). In Colombia, climate change is expected to exacerbate the incidence of pests and diseases affecting bananas, plantain, coffee, potatoes, cacao, corn, and cassava (Lau et al., 2010).

2.26 **Climate change will also bring changes in the agricultural suitability of land**. For example, in Central America, land used for coffee, corn, and bean production is expected to become less suitable for these purposes. In the case of beans, 81% of Honduran municipios currently producing this crop are expected to become unsuitable by 2030 (Bouroncle et al., 2015). In the case of coffee, the optimal farming altitude will be higher in 2050 (from the current 800-1,400 meters above sea level (masl) to 1,200-1,600 masl in Nicaragua (Laderach et al., 2009) and from 900 masl to 958 masl in El Salvador (CIAT, 2019)), thereby substantially reducing the suitable area for this crop.

2.27 **Water availability will be a risk factor aggravated by climate change.** In addition to bringing about significant changes in precipitation patterns and amounts (Fernandes et al., 2012), glacier retreat will diminish water availability and affect agricultural production in some areas (Handmer et al., 2012; Immerzeel et al., 2010). In Peru, records have for several years been indicating a loss of more than 30% in the glacier area of the Cordillera Blanca (Schauwecker et al., 2014).

2.28 **In terms of livestock farming, climate change is expected to affect the quantity and quality of fodder as well as the fertility of dairy cattle and the animals' energy for production activities** (Hristov et al., 2018). In addition, the distribution of pathogens and non-vector-borne diseases (such as foot-and-mouth disease (FMD)) will be exacerbated by the changes in temperature and humidity (van den Bossche & Coetzer, 2008).

2.29 **Fishing resources in LAC are being and will be affected by climate change through ocean acidification and rises in surface temperature and sea level** (E.H. Allison et al., 2009; Ding et al., 2017). Information on the fishing subsector is scarce in terms of not only the fish population but also the human population engaged in this activity. In the few countries in the region that have fishing censuses, these tend to be outdated or of poor quality. Notwithstanding this lack of information, projections indicate that climate change will cause a global redistribution of fishing resources (including the LAC coasts), boosting the fishing potential by more than

[17] The impacts of climate change on agricultural productivity are generally adverse, except in high-latitude areas (Myers et al., 2017; Porter et al., 2014; Smith et al., 2017).

30% in high-latitude areas and reducing it by up to 40% in tropical areas (Cheung et al., 2010).

2.30 **LAC is among the regions that are most exposed and vulnerable to natural disasters**. The 2018 Global Risks Index ranks 15 of the IDB Group's 26 borrowing member countries (out of a total of 172 countries) in the two highest risk quintiles (see Figure 17). The Agriculture sector is by nature highly vulnerable to extreme climate events. For example, between 2003 and 2013, the sector's worldwide losses due to such events amounted to US$80 billion (averaging 22% of all losses due to natural disasters). Of this total, US$11 billion was sustained in LAC (FAO, 2015). Climate change will also increase the intensity and frequency of the extreme climate events that affect the region (IDB, 2018a), further aggravating the Agriculture sector's exposure to them.

2.31 **In addition to climate events (extreme and non-extreme), Agriculture is exposed to other risks**, both production-related (such as disease outbreaks) and economic (such as market closures or price variations). To protect themselves from such risks, agricultural producers may resort to various formal and informal strategies (in addition to using ex post mechanisms to better manage the effects). In LAC, informal strategies (such as crop diversification) are the predominant form of protection against risks. Formal strategies include public programs (such as extension and infrastructure provision) and agricultural insurance (Iturrioz & Arias, 2010).

2.32 **The agricultural insurance market in LAC is still incipient but exhibits positive signs of development.** In 2014, the penetration rate of this type of insurance in LAC averaged 0.03% of GDP, higher than in Asia and Africa but lower than in the United States and Canada (0.06% of GDP on average). Furthermore, a few countries concentrate the bulk of the market: in 2014, Brazil accounted for 61% of all premiums paid in the region, while Argentina and Mexico accounted for 15% each. In addition, penetration rates were substantially higher in Brazil, Uruguay, Paraguay, Argentina, Ecuador, and Mexico (in that order) than in the rest of the countries in the region. In most LAC countries, the public sector plays an important role in the provision of insurance or in reinsurance and coexists with the private-sector companies (Swiss Re, 2016). The growth in premiums paid in the region and the development of new technologies are signs that there is a good development opportunity for agricultural insurance in the region (see IDB, 2017b for more information on the development of these markets).

B. Challenge 2. Reduce the environmental impact

2.33 **A second challenge faced by the Agriculture sector is to reduce its own impact on the environment** in order to both maintain the planet's climatic stability and biological riches and be able to continue to increase food production. Various studies argue that the current form of agricultural production is unsustainable[18] (FAO, 2018c; Searchinger et al., 2018; Tilman et al., 2001). At a global level, Agriculture contributes significantly to climate change (Poore & Nemecek, 2018; Springmann et al., 2016a; Wollenberg et al., 2016); is the largest consumer of water (FAO, 2018c;

[18] This means that the Agriculture sector currently exploits natural resources faster than they are renewed. Unless there is a change in the system of agricultural production, these resources will be exhausted, and agricultural production will be unable to sustain itself and will decline.

Hoekstra & Mekonnen, 2011; Siebert et al., 2010); and is primarily responsible for deforestation (Blaser & Robledo, 2007) and biodiversity loss (Dudley & Alexander, 2017; IPBES, 2019).

2.34 **Despite this, Agriculture is the only economic sector[19] capable of providing an extremely valuable ecosystem service, namely carbon capture**. By means of land-use changes that expand forest cover or different crop management practices (such as agroforestry), Agriculture can help to improve the soil's' ability to capture carbon. This could yield major advantages, since it is estimated that an annual increase of 0.004% in the carbon captured in the soil could practically neutralize the expected increase in GHG emissions, allowing the rise in global temperature to remain below two degrees centigrade (Orgiazzi et al., 2016). In addition, Agriculture can make a significant contribution to water security through a more efficient use of water as well as through less ground water and surface water pollution.

1. GHG emissions[20]

2.35 **In LAC, the Agriculture sector is responsible for relatively large GHG emissions, although the sector's contribution is moderate in absolute terms.** LAC accounts for approximately 8.3% of the world's GHG emissions (ECLAC, 2017). Forty-two percent of the region's total emissions (3.5% in global terms) is attributable to Agriculture and land-use change (itself primarily caused by Agriculture). This figure is slightly lower than the 46% attributable to the region's energy sector. By comparison, the global equivalents of these sector-wide figures are respectively 17% and 72% (IDB, 2018a). According to recent calculations, the Agriculture sector in LAC has reduced its level of GHG emissions per unit of output (see Figure 18); however, the carbon efficiency of production has remained unchanged (Nin-Pratt, 2019).[21]

2.36 **Deforestation is a major source of GHG emissions.** Between 1970 and 2018, more than 800,000 km^2 of Amazonian forest was lost (the equivalent of 90% of the land area of Venezuela). Of this total, 792,000 km^2 is in Brazil, where the most recent figures indicate an uptick in deforestation, due in part to a slackening of forest oversight measures (IDB, 2018e) (see Figure 19). A similar phenomenon is observed in other South American countries, driven by reasons that include forest conversion for large-scale pasture and agriculture (Bolivia), renewed access to land in former areas of conflict (Colombia), and small-scale agriculture (Peru) (Weisse &

[19] There are other human activities capable of capturing carbon (for example, reforestation). However, these activities are not part of an economic sector, in the sense that their products and services are not marketable and they are not a source of income for those who perform them.

[20] Due to the similarity of the topic, this section is closely related to some of the topics in the Climate Change SFD (IDB, 2018a). That document also includes relevant information on mitigation and climate change adaptation measures in the agriculture sector.

[21] Carbon efficiency measures the level of GHG emissions resulting from the use of a given level of inputs in production. The fact that the level of GHG emissions per unit of output has fallen and carbon efficiency has remained unchanged means that more is being produced with the same level of inputs (due to greater technical efficiency or technological change), but the same amount of GHGs is being emitted. This occurs when production rises due to loss reduction but the same quantity of fertilizer continues to be used, resulting in an unchanged volume of GHGs.

Goldman, 2019).[22] Between 2000 and 2018 the forest cover in LAC fell by 9%, primarily as a result of land-use changes in Brazil (see Figure 20). Moreover, this decline has accelerated in recent years (Elverdin, 2018; Graesser et al., 2015). Thus, LAC accounts for 47% of global GHG emissions resulting from deforestation (IDB, 2018e).

2.37 **Another major source of GHG emissions is livestock farming.** This subsector, in addition to being the principal cause of deforestation in the region,[23] emits larger amounts of GHGs than its equivalent subsector anywhere else in the world (IDB, 2018a). This is especially true of cattle farming, which accounts for approximately 68% of these emissions. Livestock-related GHG emissions in LAC have slowed, going from an annual growth rate of 1% between 2003 and 2011 to an annual growth rate of 0.6% between 2012 and 2016 (Nin-Pratt, 2019).

2. Water

2.38 **LAC is endowed with abundant water resources, but land-use change and Agriculture growth are eroding them.** Although it occupies only 15% of the Earth's land surface area, the LAC region contains 30% of the planet's fresh water resources (UNEP, 2010). However, the spatial and temporal distribution of these resources often fails to match the demand for them. According to the FAO, water extraction in the region has doubled over the last decade and is currently increasing at a rate exceeding the global average. Consequently, per-capita measures of water availability and overall water quality are falling throughout the region (IPBES, 2018). At the same time, projections suggest that, by 2050, regional demand for water will increase by 55% and water demand for agricultural purposes will rise by 59% to 127% (de Fraiture & Wichelns, 2010). As a result, 40% of the LAC population will live in watersheds under severe water stress (OECD, 2012b) and conflicts between different sectors stemming from water use will be exacerbated (Rodriguez Allende et al., 2013). Since 72% of the fresh water extracted in the region is used for agricultural purposes (UNEP-WCMC & IUCN, 2016), these challenges are closely linked to the Agriculture sector.

2.39 **The expansion of nontechnified irrigation[24] is having considerable effects on the water resources in LAC.** Spurred by great spatial and temporal variability in the availability of water, irrigation has over the last 50 years expanded at an annual rate of 250,000 hectares. It has also been observed that 26 of some 77 recently analyzed watersheds exhibit severe water shortage during at least one month per year (UNEP-WCMC & IUCN, 2016). Also as a result of irrigation, several of the region's aquifers face overexploitation and salinization problems, especially in arid areas—such as certain portions of Chile, Argentina, Mexico, and Peru—and in some Caribbean islands (Agrovoz, 2018; Nurse et al., 2014; Ringler et al., 2000). The

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[22] Some studies warn that the loss of forest cover in the Amazon jungle could increase to such an extent that the humidity and precipitation levels would not be sufficient to sustain a forest biome and the area would degrade to a savanna (Boers et al., 2017; Lenton et al., 2008; Lovejoy & Nobre, 2018; Nepstad et al., 2008; Piotrowski, 2019), irreversibly altering the rainfall patterns of the region south of the Amazon.

[23] In 2010, land-use change toward livestock farming was the cause of 70% of the deforestation in the region, while land-use change toward commercial crops such as soybean caused 14% (IDB, 2018e).

[24] Nontechnified irrigation refers to the forms of irrigation that provide limited control over the amount of water received by the plant (essentially, gravity irrigation techniques, which make highly inefficient use of water). Technified irrigation refers to sprinkler and drip irrigation techniques.

cause of overexploitation is not necessarily the expansion of irrigation systems per se, but rather the framework of water management incentives and policies. For example, Scott (2009) reported that the subsidies on electric power for irrigation systems in northern Mexico resulted in the overexploitation of several of the aquifers in the area.

2.40 **Pollution resulting from agriculture is also affecting water quality.** Fertilizers—the use of which has rapidly expanded throughout the region (FAO, 2017b)—end up running in large part to watercourses, contributing to their eutrophication and thus to the well-known growth of "dead zones" on the coasts of LAC (Wolosin & Harris, 2018).[25] Livestock farming is also a major source of water pollution, in this case organic and pathogenic (FAO, 2018a). From 1990 to 2010, this type of pollution increased in approximately two thirds of all river segments in Latin America, Africa, and Asia (UNEP, 2016) and is expected to continue to expand in the LAC region (FAO, 2019b).

3. Soil degradation

2.41 **Approximately 14% of the soil degradation worldwide occurs in LAC and is mainly due to water erosion, Agriculture, and deforestation** (FAO, 2018a). In addition to deforestation, a major contributor to soil degradation is contamination from pesticides (Niemeyer, Chelinho, & Sousa, 2017) and other agrochemicals. LAC is the world's region with the highest use of pesticides. Between 2010 and 2014, it used an average of more than 8kg/hectare, while the rest of the world used an average of 3.7kg/hectare (see Figure 21).

4. Biodiversity

2.42 **Latin America and the Caribbean is a megadiverse region, but it has been losing a part of its biodiversity at an accelerated rate.** LAC is home to 11 of the planet's 14 terrestrial biomes, and 6 of the region's countries are among the 17 most biodiverse in the world (Blackman et al., 2014). The Amazon forest alone contains more than 40% of all biodiversity in the planet (UNEP-WCMC, 2016). In addition, two of the world's eight centers of origin of crops are located in the region (Hummer & Hancock, 2015). However, the World Wildlife Fund reports that, between 1970 and 2014, vertebrate populations in LAC declined by 89%, making this the largest drop across the five biogeographic areas into which the study divides the world (WWF, 2018). Beyond vertebrates, LAC has the highest total number of threatened species (mammals, plants, fish, and birds) of any region, according to the Red List of the International Union for the Conservation of Nature (IUCN) (see Figure 22). Sixty-five percent of nature's contribution to people in LAC is declining (IPBES, 2018).

2.43 **The principal threat to biodiversity in LAC is loss of habitat, followed by overexploitation, climate change, pollution, and invasive species** (Blackman et al., 2014; IPBES, 2018). Loss of habitat is primarily a result land-use change, caused above all by agriculture and urbanization (IPBES, 2019). Expanding infrastructure also threatens biodiversity, both because of deforestation and fragmentation of habitats and because it can open new natural areas to different

[25] Since 1950, dead zones have grown four-fold in terms of size and ten-fold in terms of number. Should this trend be maintained, the marine ecosystems will likely collapse, which could ultimately lead to irreversible social and economic damage (Breitburg et al., 2018). A study calculates that this damage could range from US$200 billion to US$790 billion a year (UNDP, 2012).

threats resulting from human activity. Expanding the road network, which helps to push back the agricultural frontier, is a clear example of this and necessitates weighing the benefits of such expansion against the environmental costs.

2.44 **Land-use change affects not only the diversity of plants and macrofauna, but also, significantly, the diversity of the organisms that inhabit the soil and of insects.** In addition to its role in providing various ecosystem services (including carbon capture), eliminating soil pollution, and suppressing the transmission of some diseases, soil biodiversity is needed for Agriculture, being essential for the production and nutritional quality of food (FAO, 2019c; WWF, 2018).

2.45 **Overfishing is another major source of biodiversity loss in LAC.** The Southeast Pacific and Southwest Atlantic areas surrounding South America are among the world's most overexploited (61.5% and 58.8%, respectively, of the overexploited species), only behind the Mediterranean (58.8%) and the Black Sea (62.2%) (FAO, 2018e). Overfishing is a particularly serious problem for the coastal and marine ecosystems of LAC, and a major reason for biodiversity loss in the region. This problem is largely due to overfishing by nonregional fleets around or in the exclusive economic zones of the region's coastal countries, taking advantage of the difficulties those countries face in protecting areas near international waters (Kadie, 2018; Pauly et al., 2014). Overfishing not only creates irreparable and irreversible damage to the region's marine and coastal stocks, but also gives rise to economic losses of approximately US$20 billion per year (World Bank, 2017). In addition, the fishing industry has a highly important social dimension since it provides a livelihood for approximately 2.5 million people in the region (FAO, 2018e).

2.46 **Aquaculture can be a solution for closing the gap between a growing demand for, and a declining supply of, aquatic foods, but attention should be paid to the pressure this creates on the ecosystems.** Given the problems facing marine resources, the supply of aquatic foods is diminishing and this decline is expected to worsen. At the same time, the rise in population and the increase in its purchasing power mean that demand for these products will grow. To close this gap, aquaculture has been proposed as a potential solution. However, in order to succeed, its production would have to expand by 49.2% in LAC (and by 35.8% globally) between 2016 and 2030 (FAO, 2018e). Yet this expansion may entail environmental risks. In LAC, the growth (of more than 200%) in aquaculture production between 2000 and 2015 has created significant pressure on the various ecosystems in the region, particularly on mangroves (FAO, 2016; Wurmann, 2017).

C. Challenge 3. Reduce inequality and poverty

2.47 **In LAC, many agricultural producers, and more generally a good part of the rural population, live in poverty.** In 2016, approximately 48.6% of the region's rural population lived in poverty and 40% lived in extreme poverty (FAO, 2018b).[26] Despite a significant drop in rural poverty in most of the countries in the region, levels continue to be high, especially in countries such as Haiti, Honduras, Guatemala, and Nicaragua (see Table 1). Poverty in the Agriculture sector (i.e., in households whose primary activity or source of income is Agriculture) and rural poverty are not

[26] Meanwhile, in urban areas, the poverty rate was 26.8% and the extreme poverty rate was 7.2%.

synonymous but are closely related inasmuch as the rural economy and Agriculture affect one another.

2.48 **Agriculture is often the main driver of rural economies.** A boom or decline in the sector has immediate repercussions on rural communities, making Agriculture a very effective channel for combating poverty. Several studies have found that the growth of Agriculture is 2.5 to 2.7 times more effective in terms of reducing poverty than the growth of the nonagricultural GDP, particularly in less developed countries (Bravo-Ortega & Lederman, 2005; Christiaensen et al., 2011; Christiaensen & Martin, 2018; Foster & Valdés, 2010; Ivanic & Martin, 2018; Ligon & Sadoulet, 2007; World Bank, 2007).

2.49 **The rural areas of LAC suffer from multiple lags, which can affect the productivity of Agriculture, particularly among small-scale producers.** The distance of these areas from economic centers and their low population density affect the quality of, and access to, public services such as roads, education, health, drinking water, sanitation, electricity, and telecommunications. For example, with regard to education, LAC countries invest less in rural than in urban schools and rural students exhibit inferior performance and have lower enrollment levels (IDB, 2016a; OECD et al., 2018). With regard to basic services, 12%, 16%, and 64% of the population in the region's rural areas continue to lack access, respectively, to electricity, drinking water, and improved sanitation, compared to 1%, 3%, and 12% in urban areas (OECD et al., 2018; World Bank, 2019). The shortcomings in communication and transportation infrastructure impair market access for both inputs and products, thus reducing agricultural income. There are also significant gaps in terms of access to finance (see Section II.A). In addition to these gaps, more than half of the countries in the region have an aging rural population, with the over-50 age group growing relatively faster in rural areas than in urban ones (see Figure 23). Between 1997 and 2017, the rural population dropped from 25.8% to 19.6% of the total population, and rural employment as a percentage of total employment declined at a faster pace (28% in the case of men and 40% in the case of women).[27] In this context, since 80% of LAC's agricultural operations (comprising more than 60 million people) are classified as family agriculture (FAO, 2014; IICA, 2016), the factors that affect the living conditions of rural families also affect 80% of the agricultural operations in the region.[28]

2.50 **Gender gaps are also present.** In LAC, women have far lower access to land, credit, inputs, and even technical assistance (OXFAM, 2016) than men. In terms of employment, gender inequality is also more pronounced in rural areas. In LAC, women account for a mere 20% of agricultural jobs (FAO, 2019a), receive substantially lower remuneration than men, and tend to have lower-quality, informal,

27 World Bank Open Data, 2019. Available at: https://data.worldbank.org/.

28 This occurs when markets are not "complete" (which tends to be the case in the rural areas of developing countries) (Arias et al., 2013; FAO, 2014; Singh et al., 1986). When markets are incomplete, producers are not always able to turn to the market to purchase all the inputs and factors of production they need (including financing and labor, for example). For this reason, members of the household may be irreplaceable as employees and family savings may be the main source of financing for investments in the farm.

or temporary jobs (OECD, 2018b).[29] Moreover, women receive fewer extension services: only 5% of such services worldwide (FAO, 2011b). Between 2003 and 2013, in 15 Latin American countries, women managed on average only about 20% of all farms (from 8% in Belize and Guatemala to 30% in Chile, Jamaica, and Peru) and these farms tended to be smaller and have lower-quality land (FAO, 2017a). Furthermore, women own less land. In seven Latin American countries, women owned between 12.7% (Peru) and 32.2% (Mexico) of the agricultural land.[30] In most developing countries, rural women face greater restrictions on access to financial services than men (FAO, 2011b). For example, in Colombia, only 8% of rural women have access to credit.[31]

2.51 **The sector also exhibits significant market power inequalities. While family farms are predominant in the region, exports, input markets, and other points in the food value chains are highly concentrated.** For example, a single company exports 61% of Colombian bananas and two others export the remaining 39% (Baquero-Melo, 2017). In 2003, just three companies were responsible for more than 80% of all banana exports from Latin America (Arias et al., 2003). The case of soybeans is similar, with five companies accounting for more than 80% of soybean exports from Argentina. In Brazil, four companies account for 66.7% of orange juice concentrate exports (Briones & Rakotoarisoa, 2013). In the agricultural inputs market, the degree of concentration is even greater. Just six companies control more than 75% of the global market for seeds and more than 94% of the global market for pesticides (Berne Declaration & EcoNexus, 2013; Mooney & ETC Group, 2015; OECD, 2018a). In the case of fertilizers, 10 companies account for 41% of the global market; in veterinary medicine, 10 companies account for 81% of the global market (Fuglie et al., 2011; Hernandez & Torero, 2018; Mooney & ETC Group, 2015); and in agricultural machinery, 12 companies represent more than 60% of global trade (Elverdin et al., 2018; Fuglie et al., 2012). Finding causal evidence on the potential pernicious effects of concentration on food systems is a complex task. A study for several cities in Chile finds that concentration in the retail market for food increases prices and that these price rises do not lead to the entry of new competitors (Gonzalez & Gomez-Lobo, 2007). However, more knowledge is needed regarding the effects of these trends on the sector's efficiency and the welfare of producers and consumers. It is also important to bear in mind that efforts to reduce inequalities in market power can entail tension between the economic interests of bigger players and the others, which is a significant policy challenge.

D. Challenge 4. Provide food for a healthy diet

2.52 **A fourth challenge facing the Agriculture sector is to contribute to public health through food.** The world population faces a serious problem of malnutrition, as manifested in its three main forms: undernutrition, micronutrient deficiency, and

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[29] Part of the problem is the scarcity of early childhood education and care institutions, in many cases forcing women to remain at home caring for the children (OECD, 2018b), although cultural and social factors also play an important role (Contreras & Plaza, 2010) and may help to explain the limited demand for such institutions.

[30] FAO Gender and Land Rights Database, 2019, available at: http://www.fao.org/gender-landrights-database/en/.

[31] National Statistics Office (DANE), National Quality of Life Survey, 2014, available at: https://www.dane.gov.co/index.php/estadisticas-por-tema/pobreza-y-condiciones-de-vida/calidad-de-vida-ecv.

overnutrition (overweight and obesity). Malnutrition affects one out of every three people in the world and is responsible for 45% of the deaths of children under 5 as well as for the acute and chronic undernutrition of many others (negatively affecting their academic and economic performance). It is also the main risk factor for many noncommunicable diseases (Global Panel on Agriculture and Food Systems for Nutrition, 2016a; Lim et al., 2012; Springmann et al., 2016b; Willett et al., 2019; World Cancer Research Fund/American Institute for Cancer Research, 2018). In 2017, between 10 and 12 million deaths (22% of all adult deaths) were the result of poor diets (Afshin et al., 2019).

2.53 **Malnutrition is a problem of food insecurity** and as such has been addressed in the Food Security SFD (IDB, 2018b). However, it is briefly discussed here because the Agriculture sector has the challenge of contributing to food security by providing foods that are consistent with a healthy diet. This means producing not only a sufficient amount of food (in terms of caloric content), but also ensuring that this food is safe, of good quality, and varied enough as required for a nutritious diet.[32]

2.54 **LAC faces a severe problem of malnutrition.** Undernutrition, micronutrient deficiencies, overweight, and obesity exist side by side in the region and sometimes even within the same household. One of the main reasons for this is that the population is not eating a healthy diet (HLPE, 2018; Swinburn et al., 2019; Willett et al., 2019), but rather one that is deficient in fruits, vegetables, fiber, and whole grains, and excessive in processed meats, red meats, and sugary drinks (see Figure 24). The causes may be many and could include factors largely unrelated to the food systems, such as urbanization, income, and consumers' information on what constitutes a healthy diet. However, there are other factors associated with the food systems that affect people's diet, including price, marketing, food availability and affordability, and trade and agricultural regulations (PAHO, 2014).

2.55 **In LAC, the food systems have major shortcomings in terms of delivering varied, nutritious, and safe foods to the most vulnerable segments of the population** (Arias Carballo & Coello, 2013). The most accessible foods are often the least nutritious or even the most harmful in the long run. A research study for LAC finds that the consumption of ultraprocessed foods and drinks, which is closely associated with weight gain and obesity, has risen substantially in the region, especially in lower-income countries (PAHO, 2015). On other occasions, food availability may be limited in terms of quantity and variety, particularly among children in the poorest quintile and especially in indigenous areas (IDB, 2018c).

III. International Evidence on the Effectiveness of Policies and Programs in the Agriculture Sector

3.1 This chapter contains a review of the empirical literature on the effectiveness of various policies that affect the performance of the Agriculture sector and of food systems in broader terms. The selection and implementation of policies based on empirical evidence takes on particular importance in view of the challenges facing

[32] Food systems contribute to the four dimensions of food security (food availability, food access, food utilization, and food stability). However, this does not imply that the entire problem of food insecurity or its solution should rest on these systems, since there are other significant and unrelated factors, such as personal income. For a complete discussion, see the Food Security SFD (IDB, 2018c).

the sector. The chapter is divided into five sections. Sections B, C, D, and E are devoted to the policies that may be implemented to address each of the four major challenges analyzed in the preceding chapter. Before describing these policies, the chapter begins with a discussion of policies that cut across all four challenges.

A. Macroeconomic policies and public goods

3.2 **Macroeconomic (monetary, fiscal, foreign-exchange, and trade) policies are to a considerable extent responsible for the success of sector policies and general economic performance, including of the Agriculture sector.** According to Diaz-Bonilla (2015), macroeconomic policies impact the Agriculture sector through several channels. In the first place, they affect the income of the population and the relative price differences between domestic and foreign products, and are thus a determining factor in the demand for the products. Secondly, the levels of, and changes in, macroeconomic prices (such as the rate of exchange, interest rate, and wages) determine the relative incentives for the various economic activities, including agricultural activities. In addition, taxes and transfers (subsidies) are determinants of income. Thirdly, these policies have an effect on the availability and prices of inputs, impacting the sector's primary output as well as operation of the value chains. Fourthly, fiscal policy influences the State's capacity to invest in the provision of rural public goods aimed at the Agriculture sector. Lastly, macroeconomic policies can prevent (or lead to) economic crises, which affect growth, poverty, food security, and potential economic growth. Naturally, which macroeconomic policies are most conducive to economic development in general (and of the Agriculture sector in particular) will depend on the specific circumstances of each country and on the international context at the time these policies are implemented. However, it is worth underscoring the importance of a stable and distortion-free macroeconomic environment that leads to an efficient allocation of resources as a key factor in the development of the Agriculture sector and the efficiency of sector policies.

3.3 **Macroeconomic policies are extremely relevant to food security.** There are four dimensions to food security: food availability, food access, food utilization, and food stability (IDB, 2018c). Macroeconomic policies affect all four of these dimensions. First, given the effect they have on relative prices and on the population's income, they affect food <u>access</u>. Second, through their impact on international trade, they affect food imports and exports and, hence, food <u>availability</u>. Third, fiscal and trade policies (primarily, but not exclusively) can affect the relative price of food and, hence, food demand and <u>utilization</u>. Lastly, since macroeconomic policies are decisive in terms of overall price stability, they also affect the <u>stability</u> of food availability, access, and utilization.

3.4 **In LAC, trade policies widely takes the form of levies and import restrictions that result in higher domestic prices.** These measures provide support to domestic producers via market prices. However, at the same time, they create perverse incentives that prevent producers from boosting their productivity or shifting to more profitable areas of production. In addition, they harm consumers, including those living in poverty and malnutrition. The use of trade policies varies significantly from one country to the next. A recent analysis based on Agrimonitor data shows that Chile, Brazil, Mexico, and Uruguay use these policies sparingly (they account for less than 25% of total government support for the Agriculture sector), while most of the Andean countries (with the exception of Peru), as well as Central American and Caribbean countries, make extensive use of them, channeling between 34% and 93% of all State support for the sector through trade policies (Díaz-Bonilla and De Salvo, 2019).

3.5 **Public investment policies in the Agriculture sector may be divided into two categories: investments in public goods and investments in private goods.** Rural public goods—such as rural infrastructure (irrigation and drainage, roads, electric power, etc.), research, development, and innovation (R&D&I), agricultural health, information and statistics, land administration, and governance of common resources—[33] provide essential conditions for the development of markets and private production activities, which constitute the vast majority of agricultural production, and benefit a large number of producers. However, due to various market failures (externalities, non-excludability and non-rivalry of goods, imperfect information, imperfect competition, and coordination failures), they cannot be efficiently or sufficiently provided by private actors, making public investment necessary (Mogues et al., 2012). Private goods, in turn, tend to be simpler and less costly to provide, but their benefits are captured almost entirely by their recipients.

3.6 **In terms of sector policies, public investment in rural public goods tends to be more effective and profitable than financing of private goods.** Various studies indicate that simply redistributing public expenditure in LAC from private goods toward rural public goods would boost agricultural value added per capita (Anríquez et al., 2016; R. López & Galinato, 2007), help reduce poverty, and diminish adverse effects in the management of natural resources (Islam & Lopez, 2011; R. López & Galinato, 2007; Lopez & Palacios, 2014; Sills et al., 2015). Consistent with this, changes in the composition of rural public expenditure seem to be more important than increases in its size (R. López & Galinato, 2007): a reallocation of 10 percentage points of agricultural expenditure from private subsidies to public goods could lead to a 5% long-term increase in agricultural income per capita (Anríquez et al., 2016). Other studies have found that private subsidies have high opportunity costs when compared to investments in public goods (Allcott et al., 2006; Fan et al., 1999, 2000). In line with these findings, returns on investments in rural infrastructure, agricultural R&D&I, and rural education tend to be greater than on investments in private goods (Fan et al., 2008; Foster et al., 2011; Lopez, 2004).

3.7 **The available information suggests that the LAC countries can improve the composition of public investment in the Agriculture sector.** Firstly, many of the countries in the region devote more than half of their public investment in the sector to finance private goods (see Figure 25). A redistribution of this investment toward rural public goods would bring greater economic benefits to their Agriculture sector. Secondly, the intensity of agricultural orientation (agricultural expenditure as a percentage of total expenditure, divided by agricultural GDP as a percentage of total

[33] Not all components of the list are purely public goods. For example, agricultural health services can provide public-private or even private goods (such as certification); similarly, irrigation infrastructure is a club good. However, for the most part, these are goods that have a high degree of non-excludability or non-rivalry and are therefore not provided efficiently by the market.

GDP)[34] in the region has remained stable at 0.31 to 0.37 since 2010, compared to 0.38 in other developing countries and 1.25 in developed countries. This means that the LAC countries are devoting relatively fewer resources to agricultural development than other developing countries and developed countries (Diaz-Bonilla & De Salvo, 2019).

3.8 **The simultaneous provision of public goods creates synergies that boost the impact of investments.** A study in Peru showed that simultaneous access to two or more infrastructure services had more than proportional impacts on household income (IDB, 2018b). The FAO and the International Institute for Sustainable Development (IISD), among others, have been working on approaches to managing the critical nexus between interventions in water, energy, and food with a view to making these interventions more efficient (Bizikova et al., 2014; Hoff, 2011; IDB, 2018b), which requires complex mechanisms of intersectoral coordination (IDB, 2018b). From an operational perspective, the experience seems to suggest that these interventions should be territorially coordinated to achieve the desired synergies.[35] Given the variety of public goods in which the State may invest, their respective costs, and the scarcity of resources, it is important to develop efficient prioritization mechanisms. In this regard, representative and inclusive participation by producers and civil society, both at the territorial and at the national levels, could be crucial.[36]

3.9 **Under certain circumstances and for a limited time, smart subsidies can be a complementary targeted policy instrument.** Despite the above-described advantages, investment in public goods generally lacks immediacy and targeting ability. As a complementary measure, smart subsidies can be an appropriate instrument for targeted and immediate support. They are "smart" because, unlike regular subsidies that seek to keep the price of a good or service (such as inputs or machinery) artificially low, smart subsidies do not distort prices and therefore do not distort investment decisions in those markets. In addition, they tend to have transparent monitoring and targeting systems. Such instruments tend to be based on the delivery of vouchers or coupons that beneficiaries can use in the marketplace to purchase inputs, machinery, technical assistance, and insurance. Thus, for specific groups of producers who face multiple development restrictions—such as liquidity constraints and insufficient credit access, limited access to markets and information, and high transaction costs, among others (Feder et al., 1985)—, smart subsidies can serve as a temporary but substantive productive stimulus.

3.10 **There is evidence that smart subsidies can be effective.** By comparison to subsidies designed to alter prices, smart subsidies create fewer market distortions. In fact, they can contribute to the development of markets for inputs or technologies targeted to poor agricultural producers (Tiba, 2011). Thus, smart subsidies avoid

[34] If the intensity of agricultural orientation is higher (lower) than 1, the portion of governmental expenditure on agriculture is greater (lesser) than the agriculture sector's portion of the economy.

[35] This is precisely what rural territorial development proposes; it may be defined as "a process of simultaneous productive transformation and institutional change in a given rural territory with the aim of reducing rural poverty" (Schejtman & Berdegue, 2004). Agriculture, being the predominant economic activity in rural areas, plays an essential role in this productive transformation.

[36] The executive roundtables in Peru and the sector roundtables in Argentina are two examples of mechanisms for public-private dialogue.

some of the problems associated with the provision of direct subsidies, such as restricting private investment and delaying the adoption of more efficient technologies (IARNA & FAUSAC, 2013; Jayne & Rashid, 2013; World Bank, 2013). Consequently, smart subsidies may be used to replace other, more distortionary subsidies, enabling continued support for those producers and development of the markets. The empirical evidence shows that smart subsidies have fostered the adoption of productive technologies, achieving increases in the productivity, income, and food security of small-scale producers in Argentina, Bolivia, Nicaragua, and Uruguay (Flores et al., 2014; Mullally & Maffioli, 2014; Rossi, 2013; Salazar et al., 2015), as well as in Nigeria, Kenya, and Malawi (Awotide et al., 2013; Chibwana et al., 2010).

3.11 **Smart subsidies should be conceived of as temporary and targeted instruments.** Despite their advantages, these instruments do not provide a solution for the structural restrictions faced by producers; they only provide temporary relief from them. Moreover, they should not be conceived of as a general instrument of sector policy, since the returns on investments in public goods are far superior. Therefore, it is important to have a clear exit strategy when using smart subsidies in order to avoid keeping them in place longer than necessary. This is an area in which greater knowledge is needed, and the effectiveness and distributional effects of these instruments needs to be verified. Further knowledge is also needed on the benefits of combining production-related stimulus with conditional transfers to support producers living in poverty (and most effective way to do so).

B. Policies to increase production

1. Measures to boost productivity

3.12 **Investments in agricultural R&D&I have consistently been very profitable, and not only in LAC.** Indeed, in cases in which a comparison was made, investments in agricultural R&D&I have been shown to produce higher gains in terms of productivity than investments in irrigation, extension, and fertilizer subsidies (Diaz-Bonilla, 2015).[37] In the case of LAC, the evidence suggests that investments in agricultural research are closely related to greater economic growth, agricultural development, productivity growth, and poverty reduction (Diaz-Bonilla, 2015; IAASTD, 2009).

3.13 **Extension mechanisms make it possible to reduce productivity gaps and boost income.** Agricultural extension can have high rates of return (Jin & Huffman, 2016). The evidence shows that, in many rural contexts, women and poor farmers have more limited access to extension services and dissemination of technology, although they could obtain the greatest benefits (Ragasa et al., 2012). However, a recent study in Brazil found that rural extension—particularly private extension—boosts the income of rural households but increases income inequality (Freitas et al.,

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[37] These findings should be viewed with caution since they are based on internal rates of return (IRR) the intrinsic assumptions of which can yield overestimations. A systematic review of 2,242 investments in R&D using modified internal rates of return found that the annual yields of these investments are on the order of 9.8% rather than the previously estimated 39% (Hurley et al., 2014). Furthermore, the benefits of these investments take decades to fully materialize (Pardey et al., 2016). The modified internal rate of return (MIRR) differs from the IRR in that the latter assumes that interest rates remain constant throughout the investment. In other words, unlike the IRR, the MIRR does not assume that interim cash flows can be invested (or borrowed) at the same interest rate as that of the initial investment.

2018). Nevertheless, more knowledge and systematic information is needed on the scope and effectiveness of extension services in LAC.

3.14 **A decline in transportation costs and the quality of transportation affect access to the markets for goods and services.** The empirical evidence suggests that an investment in roads and highways has a significant effect in terms of raising rural incomes (R. Ali et al., 2015; Khandker & Koolwal, 2011; Mu & van de Walle, 2011). Specifically, an improvement in rural road infrastructure (secondary and tertiary roads) is associated with higher production (Dorosh et al., 2012; Khandker & Koolwal, 2011; Tong et al., 2013), higher household consumption (Dercon et al., 2009; Stifel et al., 2012), positive impact on employment (Rand, 2011), and higher income (Escobal & Ponce, 2008; Webb, 2013).

3.15 **Access to irrigation raises crop yields**. Various studies confirm that irrigation boosts agricultural household income and consumption (Dillon, 2011; Hagos et al., 2012; Wood et al., 2004). In Peru, the construction and rehabilitation of irrigation infrastructure boosted household consumption by 17%, production value by 72%, and sales by 83% (Del Carpio et al., 2011). In Bolivia, the PRONAREC program raised the income of beneficiary households (by 35% to 45%), sales (by 20% to 30%), and production value (by 60% to 70%), in addition to fostering the adoption of complementary technologies (C. A. López et al., 2017).

3.16 **Cost recovery is a key factor for the sustainability of irrigation projects.** A major challenge faced by projects to build or rehabilitate irrigation infrastructure is inducing users to cover the operation and maintenance costs of the infrastructure so as to ensure the sustainability of the system. The experience of several projects of this type implemented in the late 1990s or early 2000s indicates that the following steps are crucial in order to improve cost recovery efforts: (i) transfer the management of the system to a financially autonomous organization; (ii) establish a system of incentives for rate collection and payment; (iii) ensure that management of the system is highly transparent; and (iv) promote user participation in managing the system (Easter & Liu, 2005).

3.17 **Increasing land tenure security yields significant economic results.** Regularizing rural land tenure tends to boost land security and thus lead to increases in the investment, productivity, and income of agricultural producers (Lawry et al., 2014). Studies in Nicaragua and Peru show positive effects on agricultural investment, productivity, and income, and even on investment in water, sanitation, and electricity in households (Aldana & Fort, 2001; Antle et al., 2003; Deininger & Chamorro, 2004; Foltz et al., 2000; Meeks, 2018; Torero & Field, 2005). Regularization programs can even facilitate credit access by allowing the use of land as collateral. However, this theoretical possibility is not supported by the empirical evidence, suggesting that these programs should take the functioning of the credit markets into account to augment their impact (M. R. Carter & Olinto, 2003).

3.18 **Regularization of land tenure should be seen as an input for the development of effective land administration systems.** Modern land administration systems perform four basic functions: land tenure administration (for which it is important to have tenure regularity in the territory), valuation, land-use planning, and land development (Williamson et al., 2010).[38] Having an efficient and complete land administration system is important in order to lend sustainability to both land tenure regularization and the resulting economic benefits, but it is also important from a revenue collection standpoint and to enable a country to fulfill its territorial development objectives, such as establishing and preserving protected natural areas (Conroy et al., 2014).

3.19 **Information technologies improve access to knowledge and timely market information.** Some studies on Peru found that access to telephones in rural areas boosted the value of agricultural production by 16%, reduced production costs by 23% (Beuermann, 2015) and, coupled with Internet access, boosted producers' participation in the market and their likelihood of selling in the foreign market (Salas Garcia & Fan, 2015). Timely access to information on the market prices of the major crops resulted in a 13% increase in the prices at which the beneficiary producers sold their crops and a 12% increase in the likelihood of selling their crops (Nakasone, 2013). As shown by the extensive literature on Africa, information and communication technologies can facilitate agricultural extension services and expand the use of digital applications in the context of agricultural technologies.

3.20 **Associations increase social capital, the management of common goods, and the possibilities of becoming integrated into global value chains.** Access to social capital through associations empowers producers and reduces transaction costs. From the standpoint of transaction costs for farms, access to producer organizations had a positive effect on production in the case of Mexican producers (Key et al., 2000). There is also evidence that access to social capital facilitates the adoption of environmentally sustainable technologies and practices (Ainembabazi et al., 2016; Muange, 2015; Munasib & Jordan, 2011) as well as access to inputs (Abate et al., 2014; Ainembabazi et al., 2016; Francesconi & Ruben, 2012), and improves technical efficiency and crop yields (Abdul-Rahaman & Abdulai, 2018). Notwithstanding the foregoing, there is an open knowledge agenda around forming associations in LAC: the factors that determine their formation, sustainability, and effectiveness in boosting productivity and increasing producers' income, as well as in improving their integration into national and international value chains. There is also a broad knowledge agenda regarding the operation of value chains and the economic consequences of their levels of economic competition.

3.21 **Facilitating credit access in rural areas boosts the productivity and income of agricultural producers.** The empirical evidence finds, in many countries, that access to credit boosts the productivity and income of small-scale agricultural producers (Fletschner et al., 2010; Guirkinger & Boucher, 2008; Karlan et al., 2014) as well as their propensity to invest and expand their sales (Bueso-Merriam et al., 2016).[39] Collateralizable physical assets such as titled land are valued by agricultural producers. A recent study in Bolivia found that titled and collateralizable livestock

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38 The elements of a modern land administration system that can help to improve its efficiency and effectiveness include the creation of a complete and interconnected property registry integrated into a multipurpose cadastre that provides for coordinated participation by the main public and private entities with jurisdiction over the territory. The regularization processes benefit from the use of georeferenced boundary-setting techniques, participatory methodologies to determine rights, dispute resolution mechanisms, and titling and registry formalization (Conroy et al., 2014).

39 However, a metaevaluation finds that there are specific cases (certain value chains or groups of producers) in which these effects do not occur (Nankhuni & Paniagua, 2013).

farming land has a 3% greater value per hectare than similar titled but non-collateralizable land (Murguia et al., 2018).

3.22 **Animal and plant health and food safety programs reduce losses and facilitate access to new markets.** In Peru, a fruit fly eradication program benefited fruit producers of all sizes, boosting fruit production by 65%, improving production value by 15%, and increasing the proportion of fruit sold by 19% (Salazar et al., 2016). In addition, Peru's improved health status bolstered its negotiating power with other countries, which created opportunities for selling in the international markets (GRADE, 2010). In 1996 in Uruguay, attainment of FMD-free without vaccination status caused the value of meat exports to rise by more than 50%, producing additional yearly gains of about US$110 million from exports to the United States and resulting in the opening of trade to the Pacific countries and a yearly savings of US$8 million in vaccination costs (Knight-Jones & Rushton, 2013; Otte et al., 2004). According to recent estimates for 2010, food-borne diseases worldwide affected approximately 600 million people and led to the premature death of 420,000 people (Jaffee et al., 2019). It is estimated that these diseases bear a cost equivalent to US$95 billion, which could be higher if it is made to include market losses arising from destination country rejections (or bad reputation resulting from the sale) of products contaminated by disease-causing agents. At the same time, as the sector becomes increasingly integrated into global value chains, traceability systems become a key element in reducing the risks of producing and distributing contaminated food. Middle-income countries have an investment gap in this regard (Aung & Chang, 2014; Jaffee et al., 2019).

2. Measures to reduce vulnerability

3.23 **Irrigation is an effective way of reducing the risks of drought or rainfall variability** (Dillon et al., 2014; Olayide et al., 2016), making it an effective measure for adaptation to climate change. However, this virtue is tempered by irrigation's costs and impacts on water availability. In India, agricultural producers have invested in irrigation to adapt to lower rainfall volume during the monsoon, but this has allowed them to recover no more than 9% of the profits lost due to climate deterioration (Taraz, 2017). To prevent irrigation from leading to overexploitation of water resources, it should be accompanied by an appropriate framework of water management incentives and policies aimed at boosting efficiency in the use of water.

3.24 **Agricultural insurance can be an effective instrument for financial protection against climate risks.** Although the development of indexed or parametric insurance markets in LAC is limited, these policies provide an opportunity to obtain efficient coverage against climate risks. Until now, there has been little demand for such instruments, often prompting governments to step in to promote their use. However, better risk measurement based on new digital technologies and on remote sensing, as well as better design of the insurance policies, may make them more acceptable to producers. In any event, since these instruments may continue to be costly for the region's small producers, some authors have indicated the importance of combining them with other risk-reducing technologies, such as the use of resistant varieties (M. Carter et al., 2017).

3.25 **Climate-change adaptation in the Agriculture sector covers a broad spectrum of measures, ranging from the incremental to the transformative.** The former include climate-smart agriculture (CSA); the use of resilient inputs (such as droughttolerant varieties); access to irrigation infrastructure and various services (such as climatological information, technical assistance, and risk management and transfer); improvement of post-harvest and processing activities (such as access to storage infrastructure); improvement of market access; and implementation of climate-smart actions, such as social protection networks and educational campaigns (Fanzo et al., 2017; Loboguerrero et al., 2019).

3.26 **CSA is agriculture that, through a series of technologies with potential production and environmental benefits,** "sustainably increases productivity, enhances resilience (adaptation), reduces/removes GHGs (mitigation) where possible, and enhances achievement of national food security and development goals" (FAO, 2013). CSA technologies include agroecological practices such as crop rotation, minimum tillage or direct seeding, and agroforestry and silvopastoral livestock farming (Corsi et al., 2012; Fernandes et al., 2012; IDB, 2018a; Khatri-Chhetri et al., 2017; Loboguerrero et al., 2019).

C. Policies to reduce the environmental impact of agriculture

3.27 **In order to be sustainable, agriculture needs to implement fundamental changes.** These changes can foster incremental transformations through a sustainable intensification of production systems. For example, precision agriculture can reduce GHG emissions and minimize water and soil pollution through a minimal and targeted use of inputs (such as water, fertilizer, and pesticides). (Walter et al., 2017). However, the changes can also be more transformative if implemented through agroecological approaches.[40]

3.28 **Agroecology is increasingly promoted as an alternative to help in transforming the food systems.** This practice consists of applying ecological principles to agriculture. It seeks to create equitable food systems and more productive, resilient, and environmentally sustainable agroecosystems by utilizing, maintaining, and improving the ecosystem services. Agroecological principles include diversification of species, varieties, and strains at the plot, farm, and landscape level; management of habitats for biodiversity; biological pest control; improvement of soil structure and health; biological nitrogen fixation; and nutrient and waste recycling.

3.29 **Agroecology can reduce vulnerability to climate, boost productivity, and improve food security for producers.** While the evidence is still incipient, two reviews of the empirical literature find that agroecological farms with diversified systems have better yields (measured in terms of land equivalent ratio) than monoculture systems, especially in small farms (Adidja et al., 2019; Pretty & Bharucha, 2015). In Guatemala, it has been found that producers who implement agroecological practices have better availability of food and income than other producers (Calderón et al., 2018). In Nicaragua, producers who adopted agroforestry, silvopastoral, and sustainable soil management practices raised their productivity, improved their food security, and reduced their vulnerability to extreme climate events, particularly droughts associated with the El Niño phenomenon

[40] Agroecology and CSA have common elements but are not identical. Agroecology seeks to replicate the functioning and biodiversity levels of the natural ecosystems. CSA, on the other hand, does not have this ecosystem emphasis and incorporates monoculture systems as well as the use of herbicide-resistant varieties and genetically modified seeds, among other technologies (Pimbert, 2015).

(De los Santos & Bravo Ureta, 2017; Gonzalez-Flores & Le Pommellec, 2019). Also in Nicaragua, in the wake of hurricane Mitch, agroecological plots of land had wetter soil, more vegetation, less erosion, and fewer economic losses than conventional farming plots (Holt-Giménez, 2002). Given the potential benefits of agroecology, further knowledge is needed on its effectiveness and applicability on a large scale.

3.30 **Payment for environmental services (PES) is a promising mechanism to encourage the adoption of agroecological practices, but needs to be carefully designed.** The PES arrangement[41] has proven to be an effective policy for maintaining the forest cover in Costa Rica and Mexico (Busch & Ferretti-Gallon, 2017). However, the empirical evidence is still thin and is concentrated in the aforementioned countries; furthermore, other studies indicate that PES seems to have modest environmental effects and is not cost-efficient (Samii et al., 2014). In addition, the implementation of this arrangement has been closely associated with rural poverty relief projects. A review and theoretical analysis finds that many of these programs have yielded meager results because they were poorly aligned with the existing regulatory policies, were implemented by producers who for the most part had already been applying agroecological practices, failed to target the payments, and failed to implement suitable monitoring and sanction mechanisms or social safeguards (Börner et al., 2017).

1. GHG emissions

3.31 **In general terms, increases in the efficiency of the food system would bring about significant reductions in GHG emissions.** Efficiency gains could occur at all points along the chain, from input use (notably the use of nitrogen fertilizers, which produce nitrous oxide when used in excess)[42] through processing and transportation (to reduce energy consumption and losses) to the consumer (who also plays an important role in food losses and waste).

3.32 **The significance of reducing the environmental impacts of agriculture has been recognized by numerous countries in the region.** Responding to climate change requires the right combination of policies and regulatory provisions (IDB, 2018a). Mitigation efforts should not neglect small producers; their GHG emissions per capita may be small, but they emit a disproportionate amount of black carbon by burning biomass and their production is GHG-intensive (Cohn et al., 2017).

3.33 **There are various types of actions that can be implemented in the Agriculture sector to reduce its GHG emissions.** A recent review of the literature points out that various improved management practices for small producers (particularly silvopastoral systems and alternate wetting and drying of rice) can substantially reduce the intensity of GHG emissions in agricultural production. However, these practices are not sufficient to significantly lower net GHG emissions in the sector, especially considering the expected increases in output (Grewer et al., 2018). Moreover, not all these practices are accessible to all producers. Hence the critical

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41 The PES arrangement offers monetary payments to farmers and landowners to address environmental problems or provide environmental services associated with agriculture through the adoption of CSA practices (OECD, 2012).

42 Nitrous oxide is a GHG with a heat-trapping potential 298 times higher than that of CO_2 (see https://www.epa.gov/ghgemissions/overview-greenhouse-gases).

importance of developing policies that coordinate efforts and ensure that the sector's mitigation goals are achieved (Loboguerrero et al., 2019).

3.34 **There are positive instances in which CSA has made strides toward its productivity, adaptation, and mitigation goals**, but there are also cases in which the increases in productivity have resulted in higher GHG emissions (Loboguerrero et al., 2019). A positive experience has been recorded in Nicaragua, where silvopastoral practices, coupled with better management of manure, have boosted dairy productivity and reduced methane and nitrous oxide emissions from livestock (Gaitán et al., 2016).

3.35 **Livestock farming is an important area in terms of reducing GHG emissions.** LAC is the world's region with the highest volume of GHG emissions attributable to livestock farming (Gerber et al., 2013; IDB, 2018a). There are effective measures available for reducing GHG emissions per unit of animal product. They include improving the quality of fodder, making more efficient use of dietetic nutrients, implementing various manure utilization practices, and improving animal health and productivity (Hristov et al., 2018). A recent study confirms that improved cattle nutrition led to increased productivity and lower GHG emissions per unit of product in Uruguay and Paraguay (Nin-Pratt et al., 2019). Silvopastoral livestock systems also offer benefits in terms of climate change mitigation[43] and other environmental issues while raising the income of producers (IDB, 2018a).

3.36 **Reducing deforestation and forest degradation is a priority.** Since these two phenomena are responsible for approximately 15% of total annual GHG emissions worldwide and LAC accounts for 47% (IDB, 2018e), the protection of forest resources is extremely important with a view to mitigating climate change. There is evidence that reforestation and deforestation prevention are highly effective measures for capturing carbon (Griscom et al., 2017). The following subsection sets out evidence on policies to implement this protection.

3.37 **Adopting a healthy diet can also bring important benefits in terms of climate change mitigation.** Various expert panels and a growing body of literature maintain that food production consistent with healthy diets—focused on plant-based foods and lower red meat consumption—would generate considerably lower GHG emissions than the current production system (Global Panel on Agriculture and Food Systems for Nutrition, 2016b; Sarah et al., 2017; Springmann et al., 2016a; Swinburn et al., 2019; Tilman et al., 2011; Tilman & Clark, 2014; Tirado-von der Pahlen, 2017; WHO, 2018; Willett et al., 2019) and that implementing this dietary change is essential if Agriculture is to achieve the GHG emission reductions required to ensure that the global temperature does not rise more than two degrees centigrade with respect to preindustrial levels (Davis et al., 2016; Poore & Nemecek, 2018).

2. Overexploitation of natural resources

3.38 LAC is richly endowed with commonly owned natural resources, such as forests, water, and fishing resources. This raises the problem of collective action capable of

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[43] Silvopastoral livestock farming and agroforestry provide benefits in terms of carbon capture. However, these systems have yet to be fully considered in the carbon accounting approach developed by the Intergovernmental Panel on Climate Change (Cardinael et al., 2018; Viglizzo et al., 2019).

leading to overharvesting of these resources (Olson, 1965), and preventing this from happening is a major challenge.

3.39 **The first step in achieving sustainable utilization of commonly owned natural resources is to have a solid governance structure.** International best practices indicate that this entails four components: (i) a developed legal framework; (ii) an appropriate policy and institutional framework for managing the resource; (iii) information and applied research systems to inform the regulatory agencies; and (iv) monitoring, oversight, and accountability systems (Cochrane & Garcia, 2009; Cosgrove et al., 2000; OECD, 2003, 2012a, 2013). Having a solid governance structure in place, including user and civil society participation, makes it possible to establish efficient systems for sustainable exploitation of the natural resources and thus generate higher economic returns (Costello et al., 2012; Kline & Moretti, 2014; Sills et al., 2015; World Bank, 2009; Villasante, 2010).

3.40 **The protection and sustainable utilization of forest resources in LAC is particularly important, but their governance is complex.** Changes in land use in general, and deforestation in particular, have powerful impacts on the environment. Forest governance in LAC is not a simple matter, considering that forests are spread out on lands that are under different forms of ownership: 31.9% are on private land, 24.6% are on land owned by indigenous communities, 7.3% are on land designated for use by indigenous communities, and 36.1% are on public land. In view of this, governance of forest land should include the local community and combine regulations with cultural considerations (Alcorn, 2014).

3.41 **There are various forest management policies, but evidence of their effectiveness is not yet very robust** (Min-venditti et al., 2017). For example, the establishment of strictly protected areas has had positive effects on the conservation of forest areas in some cases, such as in Brazil and Costa Rica, particularly where the threat is more pronounced (Busch & Ferretti-Gallon, 2017), but not in all cases (Milder et al., 2015; Min-venditti et al., 2017; Pfaff et al., 2014). Specifically, protected areas are an effective conservation instrument when they have adequate financing and management in place, but only 16% of the protected areas in LAC do (IDB, 2018e). Communal forest management in LAC appears to have yielded positive results in some cases, although the evidence is not very robust (Busch & Ferretti-Gallon, 2017; Min-venditti et al., 2017). In any event, adequate financing and solid governance are critical to ensure the effectiveness of the protected areas, irrespective of their category (IDB, 2018e). The construction of roads in remote forest areas and the use of agricultural subsidies are associated with negative impacts on the forest cover (Busch & Ferretti-Gallon, 2017; Min-venditti et al., 2017).

3.42 **Land titling programs have had mixed impacts on forest protection.** Land tenure security tends to be associated with lower deforestation (Barbier et al., 2011; Robinson et al., 2014), as is the case in indigenous lands in the Peruvian, Bolivian, Brazilian, and Colombian Amazon (IDB, 2018e). However, another study does not find any effects on the indigenous lands in Brazil (BenYishay et al., 2017). In addition, there are cases in which tenure security increases the rate of deforestation, such as in Nicaragua (Liscow, 2013). On the other hand, it has been found that titling has positive impacts on the adoption of environmental practices and technologies for soil and water conservation (D. A. Ali et al., 2014; Deininger et al., 2011; Quisumbing & Kumar, 2014). At the same time, private initiatives (such as the

Tropical Forest Alliance 2020 and Wilmar's zero deforestation commitments, among others) aimed at reducing deforestation within a specific value chain have had measurable positive impacts but have proven insufficient and their implementation requires a combination of internal codes of conduct and sector standards. For this reason, such initiatives depend on public policies that can help overcome these challenges (Lambin et al., 2018).

3.43 **The sustainability of agricultural production requires improving the efficiency of water use for irrigation** (World Bank, 2005), which in LAC is often very low. To boost efficiency, the experience suggests providing institutions and services that can help producers grow species with fewer water requirements or acquire more efficient irrigation equipment. It is also important to eliminate subsidies that foster excessive water use. Other mechanisms include charging for water or establishing quotas, conducting user education campaigns, and establishing contracts between users and irrigation system administrators to ensure the availability of water and avoid having to store it (Easter & Liu, 2005).

3.44 **Management of the water distribution systems by irrigator associations has proven effective in improving water use efficiency, driving demand for labor, and improving dispute resolution** (Mateen, 1995; Parker, 2010). In Bolivia, an impact evaluation for the PRONAREC program—which finances irrigation systems to promote efficient water use managed by irrigator boards—shows that the beneficiaries raised their income, improved their productivity, and boosted the sales of their agricultural products (Salazar & Lopez, 2017). In the sierra region of Peru, producers succeeded in increasing water use efficiency from 22% to 72% by modernizing the irrigation systems (World Bank, 2017).

3.45 **However, improvements in water use efficiency alone are often not enough to reduce the use of water on a large scale.** The case of the Limarí basin, in Chile, is an example of how, in the absence of effective policies to limit the area under irrigation, increases in irrigation efficiency can have the perverse effect of aggravating water scarcity by lowering the costs of, and thereby boosting the demand for, irrigation (C. A. Scott et al., 2014). This underscores the need to ensure that technical advances in irrigation are supported by adequate governance and policy frameworks.

3.46 **Measures that reduce demand and those that create alternative sources of water have proven effective in certain contexts.** The international experience suggests that water markets can be effective in limiting the use of water, as is occurring in Texas (Debaere & Li, 2017) and in the central valleys of Chile (Debaere et al., 2014). However, a recent study indicates that only some countries in the region have adequate legal frameworks to create markets of this type (Endo et al., 2018). At the same time, the experience in OECD countries suggests that investments in warehousing infrastructure, reduction in distribution losses, and management of groundwater recharge through reforestation can be cost-effective measures in the medium and long term (World Bank, 2004).

3.47 **The population decline of several commercial marine species[44] throughout LAC is a problem that requires the establishment of effective management**

[44] The most overexploited species include Chilean herring, Chilean mackerel, South American sardine, bigeye tuna, bluefin tuna, and sea cucumber.

policies that can allow overexploited populations to recover. An important management tool for achieving the goals of marine and coastal reconstruction and conservation is the enactment and establishment of marine protected areas (MPAs). There is evidence that the protection resulting from the establishment of an MPA (fully or partially restricted) leads to an increase in the biomass, abundance, and average size of the marine species harvested within these protected areas (B. S. Halpern et al., 2009; S. S. Halpern, 2003; Kerwath et al., 2013; Lester et al., 2009; Sciberras et al., 2013). However, despite the benefits arising from the implementation of MPAs, it has also been shown that this measure is insufficient to fully protect the biodiversity of a marine area, especially for highly migratory species (Agardy et al., 2011; G. W. Allison et al., 1998; Bucaram et al., 2018; Christie, 2004; Kuempel et al., 2017). Consequently, the MPAs should be coupled with other policies as part of a comprehensive regulatory framework to achieve the desired conservation objectives.

3.48 **Rights-based management (RBM) systems create user incentives to improve the conservation and administration of marine resources** and thus foster a sustained rise in the profitability of fishing activities (Hilborn et al., 2004). These management systems have been implemented in several LAC countries (Edward H. Allison et al., 2011; Begossi & Brown, 2003; Castilla, 2010; Defeo et al., 2014; Hilborn et al., 2004). The main types of RBM in LAC involve the right to catch a certain portion of the allowable catch, to catch on an exclusive basis within a given geographic area, and for a group of users to manage a stock of marine resources through a well-defined membership system (Defeo et al., 2014). While most of the RBM systems used in LAC have not been properly evaluated (Orensanz & Seijo, 2013), the few impact evaluations that have been performed for this type of RBM systems have concluded that they are superior to the traditional command and control systems (Begossi & Brown, 2003; Castilla, 2010; Costello & Kaffine, 2008; Gelcich et al., 2008). Further knowledge is needed on the most effective mechanisms for managing fishing resources. Likewise, a major effort must be made to improve the information available on the sector in the region.

3. Pollution of natural resources

3.49 **The application of the polluter-pays principle (PPP) to Agriculture, such as through a pollution tax, can produce efficient and effective economic and environmental results.** However, applying this principle to Agriculture is difficult because the source of pollution is diffuse and cannot be measured at a reasonable cost. Furthermore, in many cases, demand is so inelastic that too high a tax would be needed to change the behavior of producers (OECD, 2012b; UNEP-WCMC & IUCN, 2016). However, there are some successful cases of the polluter-pays principle being applied directly to polluters. An example of this is Denmark, where pesticide use declined following the imposition of high direct taxes on users (OECD, 2012b).

3.50 **Water quality trading is a market-based instrument for pollution control that is worth exploring further.** Water quality trading establishes total emission limits for a pollutant and allows the purchase of pollutant reductions (EPA, 2019). Agricultural producers could benefit from this system since they can reduce pollutants at a lower cost than other sectors and receive an offsetting credit in excess of this cost from those unable to reduce their pollution levels. However, examples that are relevant for agricultural producer participation are few (selenium pollution in New Zealand and United States) (OECD, 2012b; Willamette Partnership et al., 2015).

3.51 **Support for conservation agriculture practices can also be provided through economic instruments, such as emission tariffs and the environmental credits market** (Ribaudo et al., 1999). However, these methods require a credible monitoring and oversight system, among other things (Blackman et al., 2018). This is a particularly formidable challenge for diffuse agricultural pollution, since the large-scale methods for monitoring pollution sources are very weak.

3.52 **Integrated pest management (IPM) has shown the potential to substantially reduce the use of pesticides with zero or even negative net cost** (Grovermann et al., 2015; Kibira et al., 2015; Muriithi et al., 2016; Sanglestsawai et al., 2015). A study of forest areas in Chile showed that the economic benefits of pest control using biological factors were 500 to 1,000 times higher than the costs (Baldini et al., 2003). In Asia and Africa, proper use of IPM has achieved 50% reductions in the use of pesticides in intensive agroecological systems (Pretty & Bharucha, 2015). Harnessing this potential is mostly a question of overcoming information barriers and certain preconceived notions prevalent among producers. In this regard, the demonstration farms have been effective in promoting sustainable practices such as IPM (Chuluunbaatar & Yoo, 2015).

D. Policies to reduce inequality and poverty in the Agriculture sector

3.53 **Policies to boost agricultural productivity that work by encouraging the adoption of technologies reduce poverty**. The Agriculture sector makes significant contributions to poverty reduction by raising income, creating jobs, and lowering food prices in rural areas (Christiaensen et al., 2011; Christiaensen & Martin, 2018). Several studies have found that the adoption of agricultural technologies reduces poverty by improving yields and labor productivity (Asfaw et al., 2012; Becerril & Abdulai, 2010; de Janvry & Sadoulet, 2009; Hagos et al., 2012; Kassie et al., 2011). In low-income countries, this poverty reduction effect is greater than that of similar productivity increases in the industry and services sectors (Ivanic & Martin, 2018). Several LAC countries have implemented transfer programs aimed at encouraging small producers to acquire technologies (examples of these programs include CRIAR in Bolivia and PATCA in Dominican Republic), with positive results on the income and food security of their beneficiaries (Aramburu et al., 2019; C. A. López et al., 2017).

3.54 **The provision of irrigation reduces rural poverty but can entail distribution risks.** In the north of Mali, irrigation access had a significant impact on production and income for farmers (particularly small producers); however, the impact on per-capita consumption was significant only for large-scale irrigators (Dillon, 2011). In Peru, an irrigation rehabilitation project on the coast led to a significant rise in production value (72%) and sales value (83%) for the largest 25% of producers, while production and sales for the smallest 25% of producers diminished (by about 65%) (Del Carpio et al., 2011). This distribution risk does not always materialize. The beneficiaries of PRONAREC, in Bolivia, raised the value of their production by approximately 44% and their household income by 27% as a result of the program (Salazar & Lopez, 2017).

3.55 **Poverty cannot be addressed solely through Agriculture in the case of producers for self-consumption** (subsistence Agriculture), who are generally the poorest in rural areas. An analysis of the complementarity of assets in developing countries suggests that joint interventions in education, land, and infrastructure could serve to improve the income levels of these producers (Foster et al., 2011). In addition, an active social protection policy focused on subsistence Agriculture areas would enable these households to improve their income generation capacity (FAO, 2012). Recent studies in LAC have identified positive synergies between rural production programs and social programs (particularly those involving conditional cash transfers) (Maldonado et al., 2016), concluding that programs that combine the two characteristics achieve lasting impacts (Banerjee et al., 2015). This is an area that requires a better understanding of the specific policies that can efficiently link together the two dimensions. Despite the positive aggregate effects of agricultural growth on poverty in the region, Agriculture's ability to reduce rural poverty in LAC has tended to be greater in areas in which producers had access to improved technology, technical and management assistance, capital markets, infrastructure, property title, insurance, or export opportunities (Da Silva et al., 2010).

E. Policies to promote the provision of a healthy diet

3.56 **The food systems have a responsibility to provide the necessary foods to enable the population to adopt a healthful diet.** This can be pursued by various means. Firstly, through Agriculture programs that consider nutrition, which are generally focused on agricultural producer households. For example, the family garden programs have succeeded in improving dietary diversity and some nutrition indicators for children and women in those households (Ruel et al., 2017). These programs have high socioeconomic potential, and further knowledge should be gained on their effectiveness and operation. Secondly, through programs that foster the production and provision of biofortified foods.[45] Thirdly, through improvements in efficiency throughout the value chain to reduce costs and losses[46] and thus enhance the affordability and availability of food. Fourthly, trade liberalization also plays an essential role in food availability and affordability since it is a determinant of how much food reaches consumers, as well as how fast and at what cost. However, it is worth noting that some studies warn of the risk that trade liberalization will facilitate the so-called nutrition transition[47] and affect the health of the population through the increased availability of ultraprocessed foods and sugary drinks. Lastly, the food systems also have the responsibility of ensuring that foods are safe and using labels to warn of the potential nutritional risks of consuming them. The Food Security SFD provides an extensive review of the empirical evidence on the effectiveness of these programs and policies (IDB, 2018c).

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[45] Biofortified foods are those that have been genetically modified to increase the content of one or more specific nutrients.

[46] FAO estimates that 30% of all food production is lost at some point in the chain between the farm and the consumer (FAO, 2011a), but this figure may be an overestimate (Bellemare et al., 2017).

[47] Nutrition transition denotes the adoption by the population of "a diet with higher energy density, which means more fat and more added sugar in foods, an increased intake of saturated fats (primarily from animal sources) coupled with a reduced intake of complex carbohydrates and fiber, and lower consumption of fruits and vegetables." (WHO, 2003).

IV. LESSONS LEARNED FROM THE IDB GROUP'S EXPERIENCE IN THE AGRICULTURE SECTOR

4.1 The lessons learned highlighted in this section are taken from the analysis of a sample of 19 sovereign-guaranteed operations[48] and 4 IDB Lab projects,[49] as well as from a review of lessons learned set out in other related documents. This analysis was based on a review of documents related to the selected projects[50] as well as on interviews with the project team leaders. Below is a summary of the main lessons learned, grouped in terms of their alignment with the above-described challenges. A lesson learned that cuts across all operations in the sector is the need to strengthen the capacity for monitoring and evaluation of the intervention outcomes. The need to continue to expand knowledge on the development effectiveness of the projects in the sector is still extensive.

A. Lessons aligned with the challenge of boosting production

4.2 The IDB Group has worked with the countries to address this challenge, fostering conditions aimed at enhancing productivity and reducing the vulnerability of the sector.

4.3 **There is a need to foster agricultural and fishing innovation through scientific research as a solid basis for identifying leading-edge technology and integrating it into the market, transferring knowledge, and promoting sustainable management of resources.** The Bank has been supporting innovation through knowledge generation in the form of leading-edge technology outputs and agricultural and fishing-related training and research activities. The Bank should strengthen academic ties with international research institutions (e.g., CGIAR centers or other international agencies), universities, other research institutions, and the private sector.

4.4 **In the Bank's experience in agrifood health projects, institutional strengthening stands out as the focus of attention during implementation.** Accordingly, the Bank should support strengthening and empowering the institutions in the food health and safety system by: (i) implementing international good practices; (ii) creating and implementing cost recovery mechanisms to ensure the sustainability of the system; and (iii) creating and implementing mechanisms to ensure interinstitutional coordination and the participation of relevant civil society and private sector actors. It is important to carefully prioritize support in the area of agrifood health based on quantitative economic analyses so that investments can be concentrated on the activities that will generate the greatest benefits for the countries rather than be diluted in a multiplicity of activities.

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48 The analyzed operations, approved after 2016, are: EC-L1071, ME-L1045, AR-L1064, BR-L1152, PR-L1001, UR-L1016, BO-L1106, PE-L1026, GY-L1060, HA-L1059, HA-L1097, AR-L1067, AR-L1068, BR-L1289, CO-L1166, SU-L1052, DR-L1120, BR-L1496, and UR-L1147.

49 The IDB Lab projects forming part of this documentary review are: RG-Q0048, NI-T1231, RG-L1120, and SU-T1096.

50 This exercise was carried out through a review of project completion reports (PCRs), project monitoring reports (PMRs), loan proposals, technical notes, impact evaluations, OVE evaluations, and other relevant documents.

4.5 **Rural land administration programs should operate under technical and methodological principles aimed at consolidating the cadastral formation in the territory, including legal clearing of title in order to provide clear and full property rights.** The Bank's operational experience suggests that the following considerations should be taken into account: (i) the legal framework should make it possible to perform rural titling under uniform parameters and controls; (ii) the arrangements for coordination between cadastre and registry should facilitate introduction of the use of georeferenced information to obtain clear property rights (in particular, the use of comprehensive and interoperable information technology solutions is recommended); (iii) the facts on the ground should be reconciled with the legal information in the real estate registry at the time the cadastre is formed; and (iv) the communities should actively participate in the tenure regularization and land titling process.

4.6 **Participation by all agents in the value chain is essential.** In particular, active participation by the main value chain stakeholders (such as cooperatives, anchor companies, representatives of rural communities) facilitates coordination and monitoring of the interventions, encouraging agricultural producers to comply with the quality standards requirements for gaining access to markets and promoting the sustainability of the interventions. In certain categories, scale can be important to boost production units' productivity, and the IDB Group can have a powerful impact financing their economic expansion projects, taking care not to harm the environment or the level of market competition. For medium-scale products, the IDB Group can provide the highest degree of financial and nonfinancial additionality by offering them customized financial solutions (with longer maturities and greater flexibility) that address their specific financial challenges, as well as by supporting their efforts to strengthen their environmental and corporate governance practices.

4.7 **New technologies and methods to calculate climate risk have contributed to the development of new climate-related risk transfer products (e.g., insurance), but the benefits should be communicated more effectively.** The new digital technologies for obtaining data (e.g., remote sensing via satellite, radar, or drone), coupled with methods of open data analysis, have led to the development of new types of agricultural insurance against climate risks at a lower cost. However, with a view to fostering their market penetration among small and medium-sized producers, beneficiaries should be trained and there should be communication campaigns aimed at producer associations and providers of agricultural inputs to explain the value added of these insurance instruments and how they work.[51] In addition to risk transfer instruments, diversification in terms of products and geographic location is crucial for reducing risks associated with climate and volatility of commodity prices.

B. Lessons aligned with the challenge of reducing the impact of Agriculture on the environment

4.8 The work of the IDB Group has been directed at promoting agroecological practices, CSA, and policy and governance frameworks aimed at fostering sustainable use of natural resources.

[51] HA-L1059, UR-L1147, and RG-Q0048.

4.9 **In this regard, the IDB Group's technical and financial assistance to small producers in formulating community plans and implementing agroforestry and silvopastoral systems makes it possible to assure environmental conservation.** The IDB Group has been supporting programs designed to combat deforestation and promote biodiversity conservation while encouraging social inclusion and income generation in rural communities. The experience highlights the importance of supporting small-scale producers with resources aimed at: (i) maximizing the local technical capabilities; (ii) strengthening the sharing of experiences among the members of a production chain or between producers, with a view to integrating the knowledge that has been generated; (iii) financing technology that can facilitate the establishment of agroforestry systems; and, as the case may be, (iv) promoting synergies among beneficiaries for the purchase of inputs and for obtaining access to new markets, using the tools made available through associations.

4.10 **Investments in irrigation systems should consider conditions that can contribute to a sustainable management of the infrastructure and associated water resources.** In this regard, the Bank should: (i) seek to transfer management of the irrigation systems to the users themselves or to specialized companies as a way of efficiently helping to bolster the projects' possibilities of success; (ii) pay attention to the challenge of water shortage, introducing measures for integrated management of the resource at the watershed level for an efficient cross-sector allocation and greater efficiency in water use for irrigation; and (iii) have an adequate incentives framework in place to promote the use of water conservation technologies among producers.

4.11 **With regard to fishing resources, the Bank should ensure that conditions and incentives are created for the establishment of property rights over the resource to assure its sustainability in the future and prevent open access and the resulting overexploitation.** A system that grants property rights, is based on socioeconomic and scientific information, provides for adequate oversight, and does not include fishing subsidies will ensure sufficient biomass levels for future extractions.

4.12 **Reducing the pressure on natural resources requires having robust monitoring systems and information systems to support them.** The experience of the IDB Group shows the importance of having monitoring systems based on robust indicators so as to be able, for example, to properly monitor deforestation or watershed management in irrigation systems. In addition, these monitoring and information systems can help to improve systematic and comprehensive measurement of the impact of agricultural investments aimed at fostering a sustainable use of natural resources.

4.13 **The private sector is a key actor in terms of innovation in environmentally sustainable practices and technologies.** The experience of the private sector in developing environmental management programs and adopting clean production technologies yields some valuable lessons. First, it is important to sensitize and train all stakeholders involved. Second, market-based instruments can improve environmental sustainability, as in the case of forest certification, which incentivizes companies to produce or use wood from sustainably managed forests.

C. Lessons aligned with the challenge of reducing inequality and poverty in the Agriculture sector

4.14 Working with various members of the value chain, particularly small producers, has been one of the areas of focus of IDB Group operations in the Agriculture sector. The efforts of the IDB Group in this area have focused on overcoming the restrictions faced by small producers and on the purchase of inputs or technologies, seeking to help boost productivity and reduce inequality and poverty in the sector.

4.15 **Direct transfers to producers for the purchase of technologies should take into account the restrictions faced by producers, with a view to ensuring that the technology being adopted is sustainable.** The IDB Group's work in financing nonreimbursable direct transfers and technical assistance to rural producers has facilitated the adoption of technologies by beneficiaries. As shown by the experience in this regard, it is important to ensure that the design of these projects considers (i) the return on the technologies to be promoted; (ii) the cofinancing percentage required of producers to strengthen the sustainability of the technologies received and create a true leveraging effect on the investment; (iii) making receipt of the direct transfers subject to compliance with clearly defined conditions; and (iv) emphasizing technical assistance for the use and maintenance of the technology.

4.16 **The technical assistance should take into consideration the specific limitations of the location and the socioeconomic profile of the producers to ensure proper adoption of the technology being offered and, to the extent possible, use innovative models that take advantage of information and communication technologies.** In particular, it is crucial (i) that the knowledge transfer be carried out repeatedly to ensure that the providers and the producers learn, share, and assess the conditions of the technologies on offer; (ii) to ensure that the technical assistance is provided for as long and as frequently as necessary; and (iii) to take the demographic characteristics of the agricultural producers (e.g., age and gender) into account, since they can result in differentiated effects in terms of the rates of adoption of new practices.

4.17 **Projects focused on boosting the yield of agricultural producers through the adoption of more resilient practices or technologies benefit from the presence of anchor companies with an inclusive approach.** The experience of IDB Lab shows that, in agribusiness and value chain financing projects, small producers benefit from the catalytic role played by anchor companies, since these companies can facilitate the introduction of technologies, modernization of the producers' practices, financing of their production, and linkage with other markets. To this end, it is important to select anchor companies that are technically and organizationally sound and have an inclusive approach consistent with their business model.

D. Lessons aligned with the challenge of providing food for a healthy diet

4.18 The IDB Group has worked on this and other food security-related objectives through various operations.

4.19 **In terms of increasing the availability of food, programs are more effective when they focus on the production and commercial needs of the small producer.** First of all, this requires good targeting, based on objective criteria. Second, boosting the productivity of small producers requires providing solid technical assistance during two or more agricultural cycles, relying on the support of trained technicians. Third, there needs to be an emphasis on integrating these producers into the value chains. To this end, it is important to improve the connectivity of producers with markets, such as by building or rehabilitating rural roads. The experience shows that these interventions increase the incentives for production diversification. In all of the above, it is important to foster full participation by women and vulnerable demographic groups, addressing their specific needs.

4.20 **Another important consideration is to ensure that the food being provided is safe.** To a large extent, this depends on the animal and plant health and food safety services. The experience of the IDB Group is aimed at strengthening and empowering these institutions through the implementation of international good practices, continuous financing, implementation of cost recovery mechanisms, and interinstitutional coordination. Food safety also depends on how the food is produced. The IDB Group has made efforts to promote the introduction of good agricultural and livestock farming practices. However, in order for these efforts to be effective, an incentives mechanism needs to be implemented to reward the production of safe food (or penalize the production of harmful food).

E. Crosscutting and operational lessons

4.21 **Interinstitutional coordination is a key to the success of many operations.** For example, operations aimed at agrifood health and sustainable management of natural resources require close coordination among various institutions. Projects of this type entail not only technical and administrative activities with the executing agency but the implementation of effective mechanisms for coordination with other public agencies. Projects often create coordination bodies that are highly valued for their contribution to the work of interdisciplinary groups. However, these bodies need to have high-level political support, be backed by institutionally solid entities, and have economic resources to finance suitable management tools.

V. LINES OF ACTION FOR THE IDB GROUP'S WORK IN THE AGRICULTURE SECTOR

5.1 This SFD proposes that the IDB Group's activities focus on helping the Agriculture sector in Latin America and the Caribbean be sustainable by seeking to boost the productivity, production, and economic activity of food systems in the region at the national and international level, reducing the impacts on the environment, placing an emphasis on ensuring that small producers have real opportunities to successfully join in the sector's transformation, and adopting a comprehensive vision of the food system aimed at ensuring that it provides the necessary food for a healthy diet. Based on the diagnostic assessment set out in Section II, the review of the literature contained in Section III, and the lessons learned systematized in Section IV, this SFD proposes five lines of action. These lines of action are intended as a reference for the work of the IDB Group and should be adapted to the context of each country. To the extent that there are overlaps with other SFDs, the lines of action set out below will be consistent with the guidelines of those SFDs, on the understanding that most of the challenges of the Agriculture sector should be addressed on an integrated and multidisciplinary basis. Moreover, the support the IDB Group offers its member countries should take into account institutional constraints and the political economy of each national or local context where that support is provided.

1. Line of action 1. Foster investments that assist in boosting the productivity of the Agriculture sector in line with a sustainable management of natural resources

5.2 **The region needs to make policy reforms to promote the development of efficient markets for factors and products, encourage private investment in rural areas, and enhance the efficiency of agricultural public expenditure.** Agricultural activity is, primarily carried out by the private sector. Accordingly, ensuring that conditions are favorable for private investment is of the utmost importance, including, notably, investment in innovation. This requires improving the quality and coverage of the public goods and services that allow Agriculture to develop, such as: (i) the national agricultural innovation systems (emphasizing public-private collaboration; work in leading-edge–such as digital and gene editing–technologies, particularly those promoting CSA; and improvement of extension services); (ii) animal and plant health and food safety systems; (iii) rural infrastructure (focusing on the poorest and most vulnerable population groups and seeking to reduce vulnerability to natural disaster risks); (iv) land administration (including tenure regularization, with an emphasis on protecting the rights of the poorest and most vulnerable demographic groups); and (v) information and statistical systems (including biophysical and climate considerations that make it possible to anticipate the future agricultural suitability of the various areas of the countries as a result of climate change). The improvement in these goods and services will have to be sustainable over time, which means ensuring their financial sustainability, including operation and maintenance costs when applicable. In order to be effective, these reforms should be informed by social consultation processes in the communities or sectors in which private investment is to be encouraged.

5.3 **In addition, the countries in the region can improve other important economic conditions that can be determinants for investment in the sector.** Small and medium-sized producers have limited access to credit and other financial instruments, such as agricultural insurance. Improving such access is crucial for enabling investments that could boost the sector's productivity, reduce its environmental impact, and diminish its vulnerability (thereby raising productivity) to market risks, particularly climate risks, whether current or arising as a result of climate change. Another area of opportunity is improving the efficiency of the value chains by promoting investment (whether private, public-private, or public in the case of public goods) in bottlenecks and missing links (for example, storage, cold chain, and health inspection stations) to reduce losses and improve access to the national and international markets. Creating the conditions for fostering the entry of new participants in various segments of the value chains will be important in order to boost competition.

2. Line of action 2. Foster a sustainable Agriculture that reduces and offsets its impact on the environment

5.4 **From an economic standpoint, the environmental impact of Agriculture is due to the fact that the cost imposed on society (a negative externality) is included neither in the production costs nor, consequently, in the consumer price (i.e., the externality is not internalized), so that there are no economic incentives to reduce the impact.** For that internalization to take place, it is essential to improve the governance of the natural resources (water, air, land, forests, and marine and riparian resources) and implement instruments for managing them. This can be done by strengthening the technical and operating capacities of the authorities in charge of managing natural resources in aspects such as information systems, monitoring, funding control, and design of governance and oversight systems, focused on the most sensitive areas. It is also important to strengthen these capacities in members of civil society, communities, and consumers. The IDB Group will be ready to provide support on these issues as well as in the design of public policies and natural resource management systems that are adapted to local conditions and are based on the granting of property rights, including strengthening the revenue collection and administration functions to improve funding for the management of these resources.

5.5 **Natural resource management requires a solid information, planning, monitoring, and evaluation system.** The technical work of the IDB Group will help consolidate the knowledge and information available to the authorities involved in natural resource management regarding socioeconomic considerations related to the use of those resources, their stocks, and production. This information is required in order to prepare management plans (for fishing areas, forest ecosystems, hydrographic basins, or others) that may be agreed upon between the public and private sectors. In tandem with these plans, it is important to establish indicators and monitoring arrangements to track the sector's strides toward environmental sustainability (such as GHG emissions, land-use change, deforestation, and pollution levels, among others), whenever possible incorporating this information into the sector statistics and information systems. The technical work of the IDB Group will also support the preparation of these plans, indicators, and monitoring arrangements.

5.6 **One supplementary policy to reduce the impacts of Agriculture on the environment is to incentivize the provision of ecosystem services, such as through agroecology.** The IDB Group will provide technical support in identifying and implementing cost-effective and financially sustainable instruments to encourage the provision of ecosystem services through the adoption of agroecological practices.

3. Line of action 3. Develop and implement instruments that sustainably boost the income of small agricultural producers

5.7 **In LAC, the Agriculture sector's markets often exhibit various failures that create inefficiencies and reduce the profitability of small producers.** Some of these failures can be mitigated or even resolved by providing the public goods and services described in the first line of action. However, the region's small agricultural producers often face multiple and profound market failures that result in limited access to the markets (for both factors and products), high transaction costs, liquidity constraints, and lack of access to finance, among other restrictions. In some cases, where these problems are particularly serious and are coupled with others such as limited agricultural suitability of the land, agriculture alone can hardly provide a way out of the poverty that tends to prevail in these contexts. In those cases, the IDB Group will offer technical support to analyze and design programs that combine interventions designed to boost agricultural productivity with social protection interventions. Since women and other vulnerable population groups face disadvantages in the sector, the programs will have to adopt an approach aimed at eliminating those disadvantages. In all cases (and more generally in all interventions targeting a specific demographic or producer group), the IDB Group will take the characteristics of the beneficiaries and the (economic, social, and environmental) context into account to adapt the interventions accordingly.

5.8 **The development of agricultural operations will be fostered in cases in which Agriculture can be profitable, i.e., when market failures are not extreme and are not coupled with other aggravating factors.** To this end, the IDB Group will offer support in developing cost-effective incentive mechanisms for the adoption of profitable and environmentally sustainable technological innovations that can help producers adapt to climate change, with a particular emphasis on vulnerable groups such as women and ethnic minorities. In coordination with the private sector, the IDB Group will also explore mechanisms for fostering credit and guarantees with a view to financing key links in value chains or providing financing directly to small and medium-sized producers to address their working capital or capital investment needs, including funding and technical assistance to intermediary financial institutions. Also in coordination with the private sector, the IDB Group will promote the fostering of investments that support agribusinesses aimed at agroindustrial transformation and innovation as well as companies that stimulate the development of business partnerships. In doing so, the IDB Group will emphasize fostering access to credit, basic inputs, and productive investment capital for small and medium-sized producers. At the same time, it will emphasize investments aimed at the modernization of logistics infrastructure, stockpiling, and postharvest management, as well as investments to promote the integration of producers into export markets.

4. Line of action 4. Support production of the necessary foods for a healthy diet

5.9 **In view of the malnutrition problems faced by LAC, food systems should step up their efforts to provide the population with the components of a healthy diet.** To this end, the IDB Group will offer support in the implementation of nutrition-sensitive Agriculture interventions, considering the needs of each country's food system. The IDB Group will also be ready to support the development and dissemination of varieties with higher micronutrient content in the context of agricultural research programs. Moreover, the IDB Group may collaborate in promoting actions aimed at increasing the supply of these and other foods with high nutritional value as well as actions aimed at educating consumers on the nutrition quality of the food on offer, while at the same time helping to reduce the environmental impact of Agriculture in LAC.

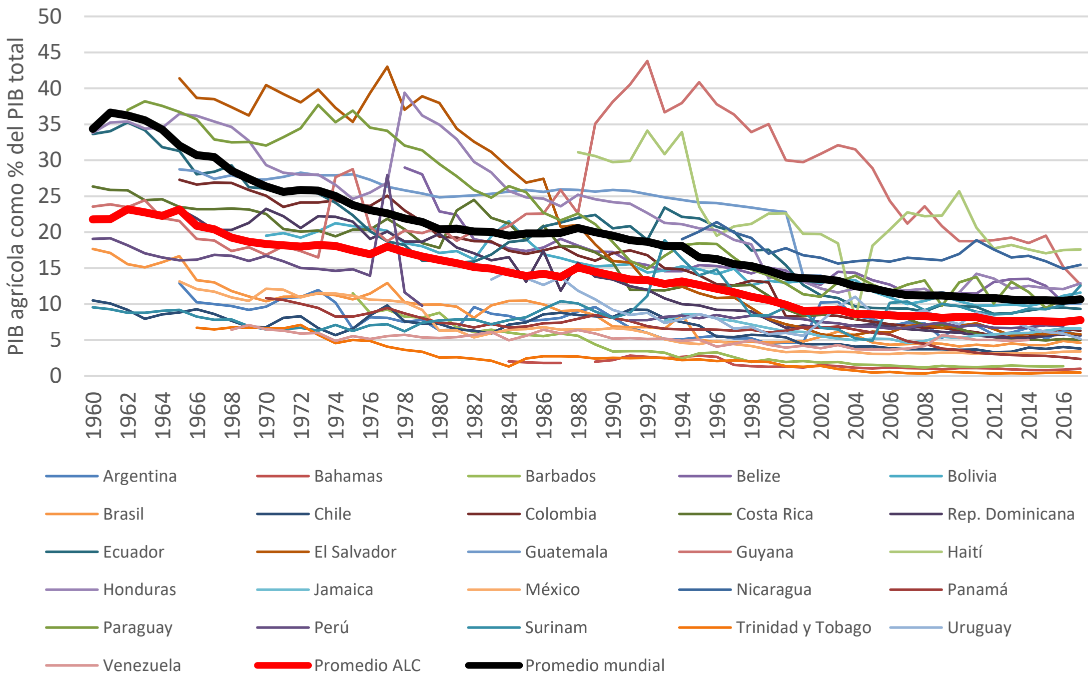
5. Line of action 5. Knowledge agenda

5.10 **Under the four preceding lines of action, the IDB Group will seek to increase knowledge on the effectiveness of the programs and policies it supports.** To this end, the IDB Group will promote open regional dialogue with participation by the public and private sectors that helps to guide the work of the IDB Group. As input for that dialogue, the IDB Group will analyze the functioning, cost-effectiveness, and impact of flagship projects, using the most rigorous methodologies available. In addition, in the projects it finances, the IDB Group will seek to include various measures aimed at expanding knowledge on nudges and mechanisms that modify behavior so as to make more efficient use of the natural resources needed for agricultural production, introduction of risk transfer instruments, changes in consumption patterns, and others. The results of these analyses will be disseminated within and outside the countries in which the projects are carried out, with a view to sharing knowledge and experience among LAC countries.

5.11 **In tandem with the foregoing, the IDB Group will develop a knowledge agenda on a series of relevant issues on which there is little information.** These issues include the following: effectiveness of agroecological practices; effectiveness and distributive effects of agricultural subsidy programs; effectiveness of production promotion programs combined with conditional transfers; extension services, associations, and social capital; fishing subsector; operation of value chains in the region; and effectiveness of agricultural policies that take nutrition into account. In addition, on a crosscutting basis, the IDB Group will continue to seek to consolidate the estimation of support for Agriculture. Lastly, the IDB Group will be attentive to the emergence of new, disruptive phenomena (e.g. technological, climatological, commercial, etc.) to include them on a timely basis in its knowledge agenda and to inform the dialogue with its member countries.

FIGURES AND TABLE

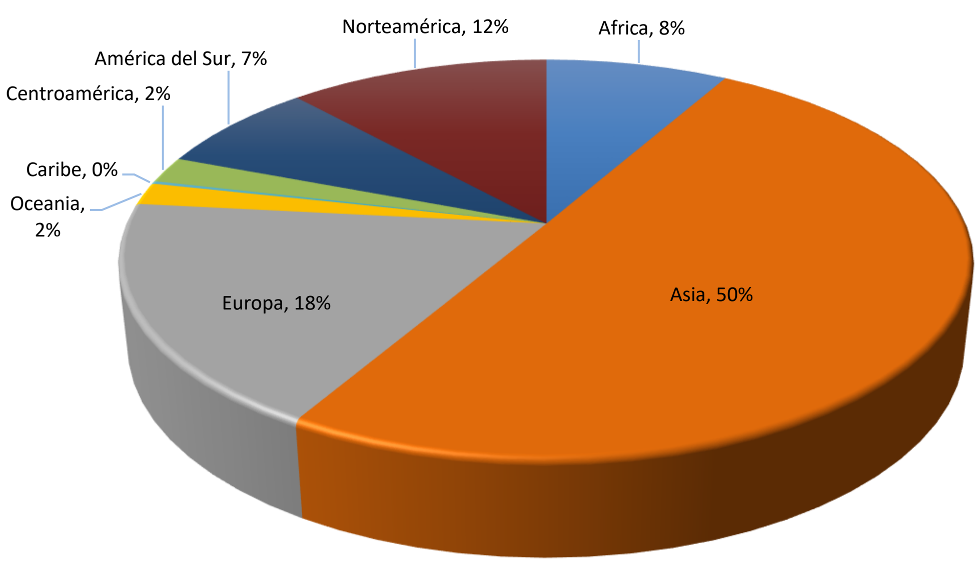
Figure 1. Agricultural value added as a percentage of GDP over time



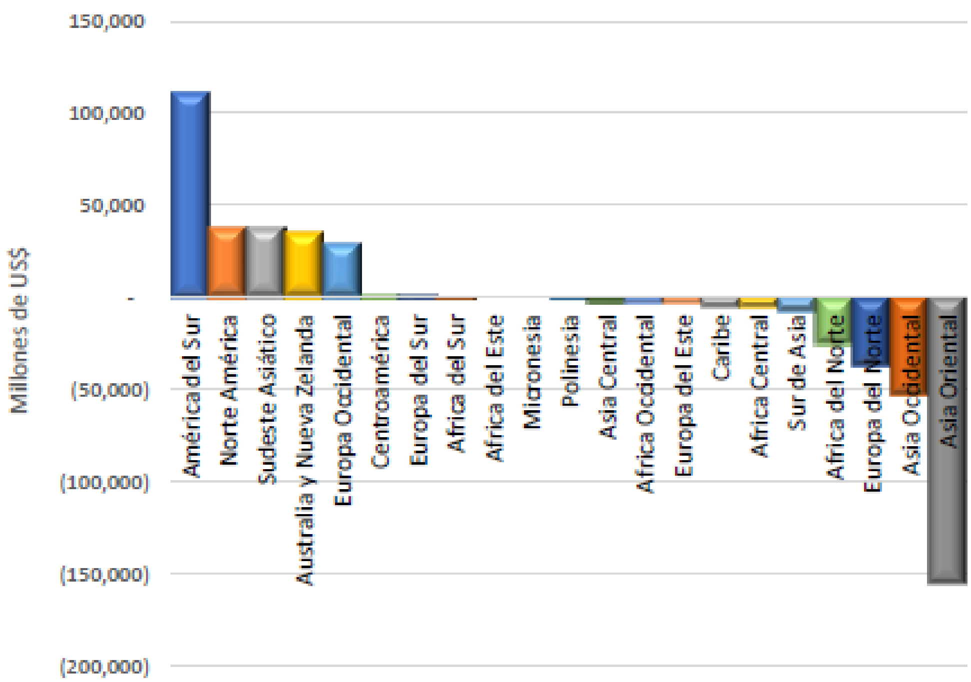
Source: Prepared by the authors using data from the World Bank (2019).

Figure 2. Global gross agricultural production and net agricultural exports

Panel a. Gross agricultural production, 2010-2016 average



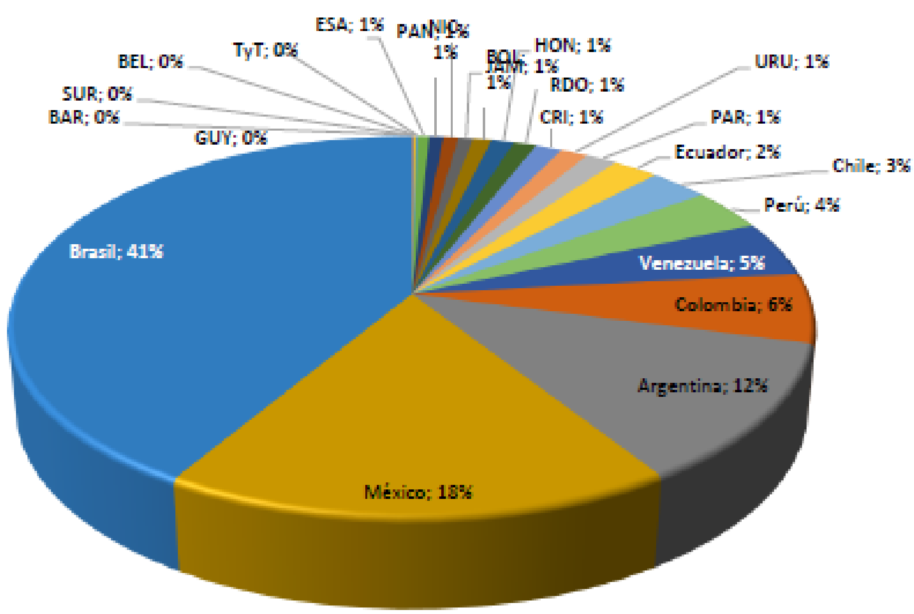
Panel b. Net agricultural exports, 2010-2016 average



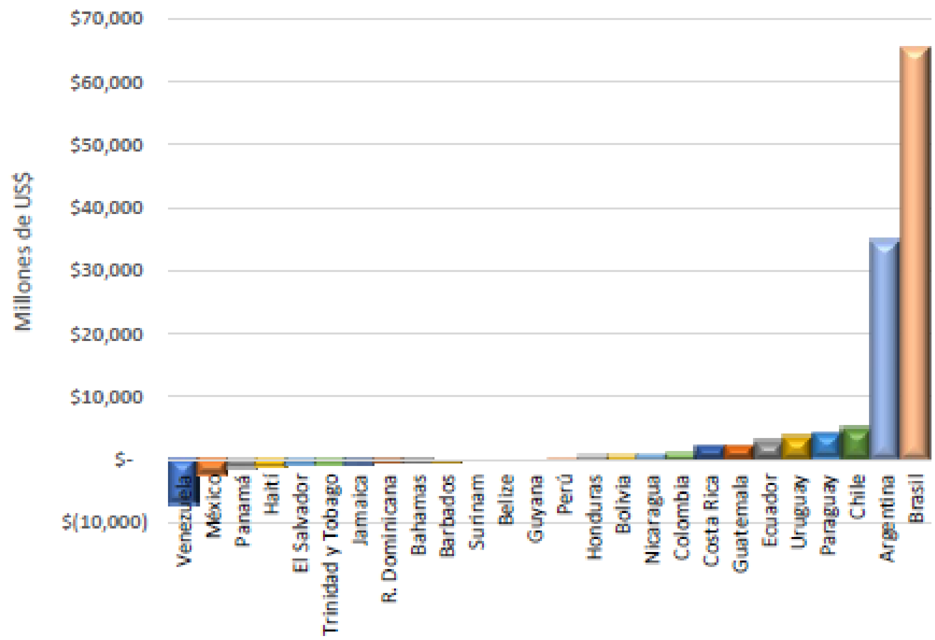
Source: Prepared by the authors using data from FAOSTAT, 2019.

Figure 3. Agricultural gross production and net exports in LAC

Panel a. Gross agricultural production in LAC, 2010-2016 average

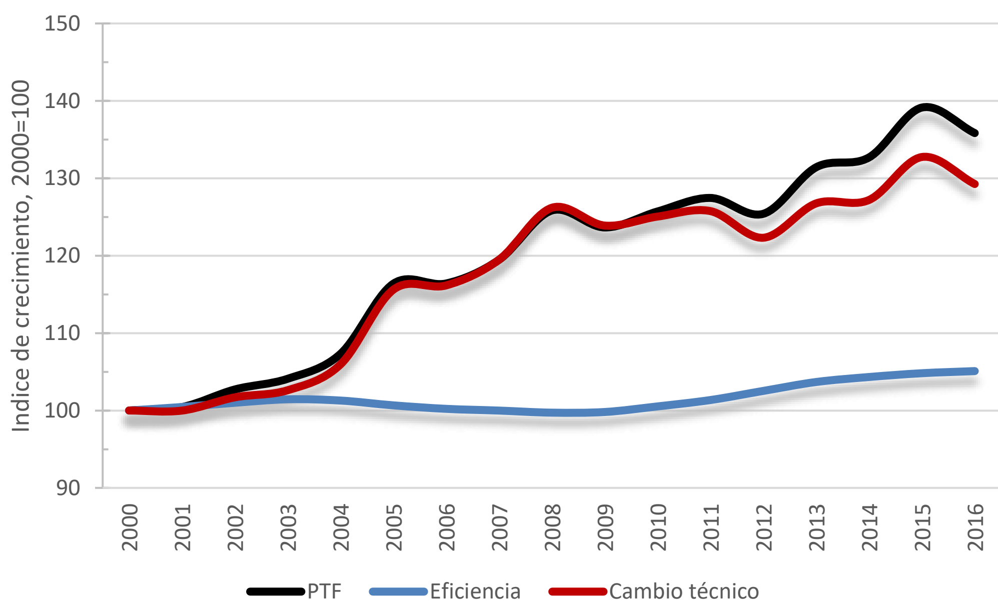


Panel b. LAC net agricultural exports, 2010-2016 average



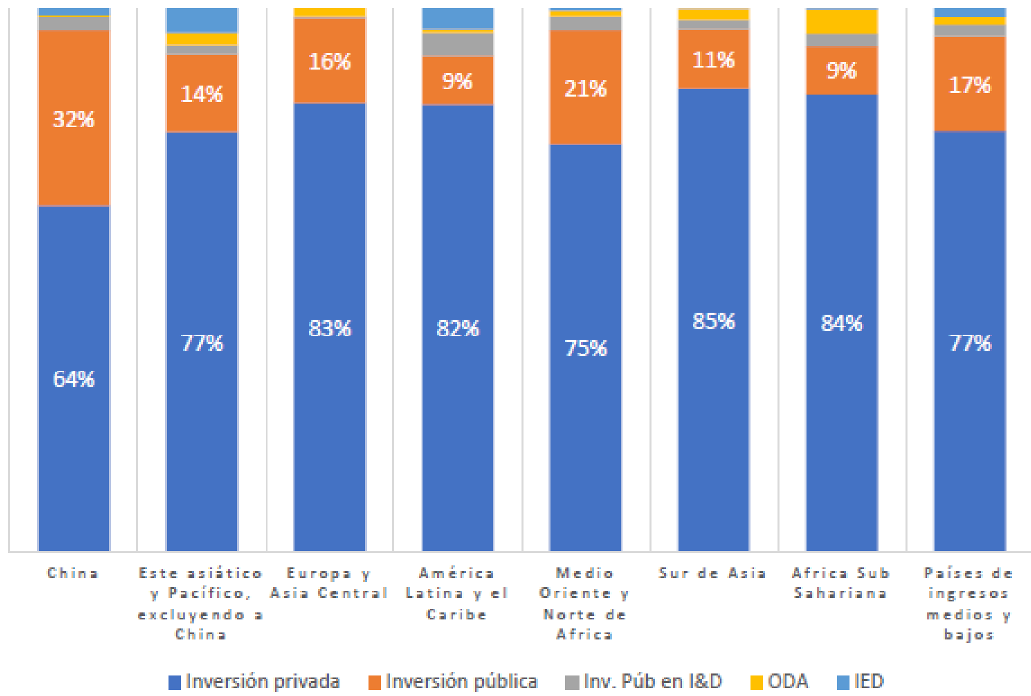
Source: Prepared by the authors using data from FAOSTAT, 2019.

Figure 4. Breakdown of TFP into efficiency and technical change



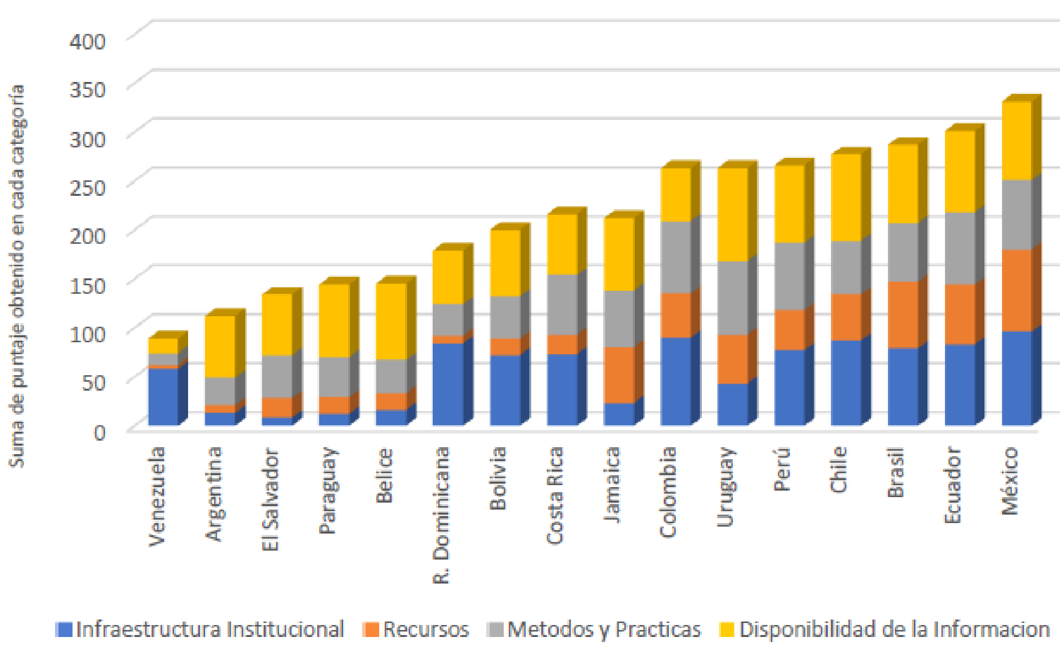
Source: Nin-Pratt (2019).

Figure 5. Sources of investment in the Agriculture sector



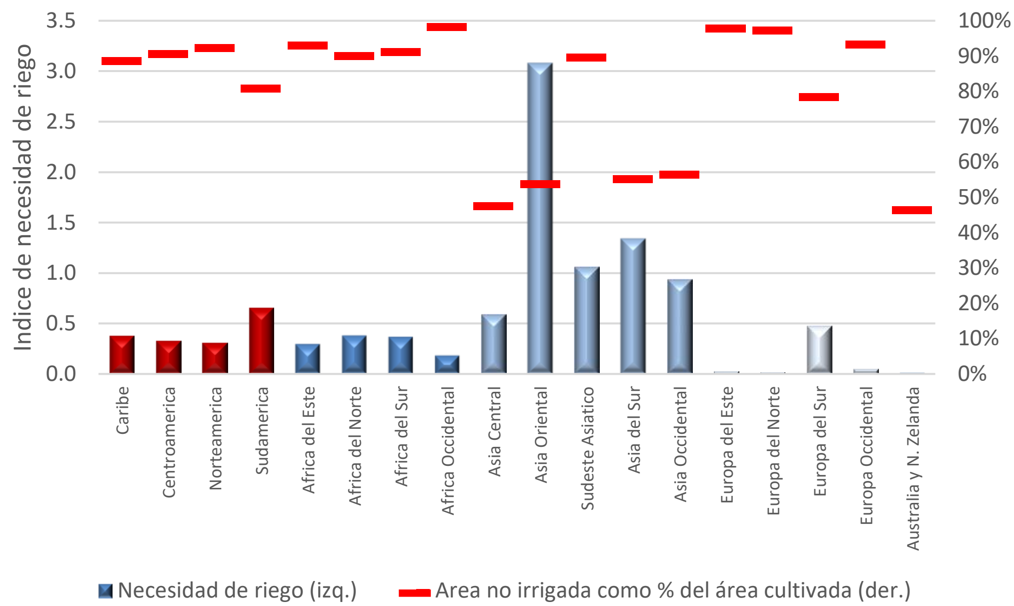
Source: Prepared by the authors based on data from Lowder et al., 2012**.**

Figure 6. Capacity of the agricultural information and statistics systems, LAC 2013



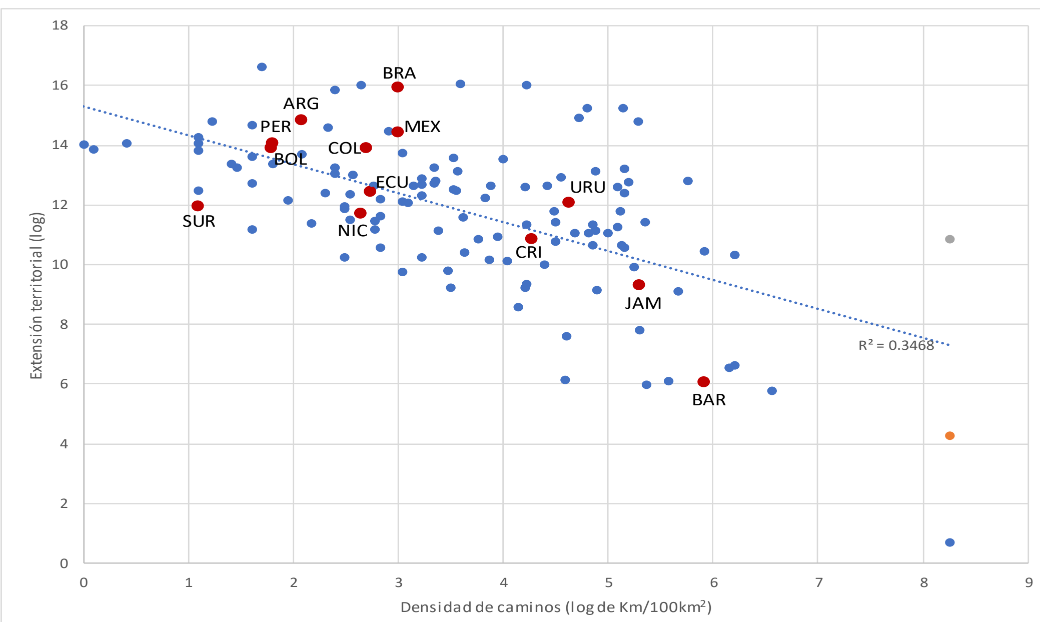
Source: Prepared by the authors based on data from Galmes, 2013.

Figure 7. Percentage of non-irrigated agricultural area and irrigation needs



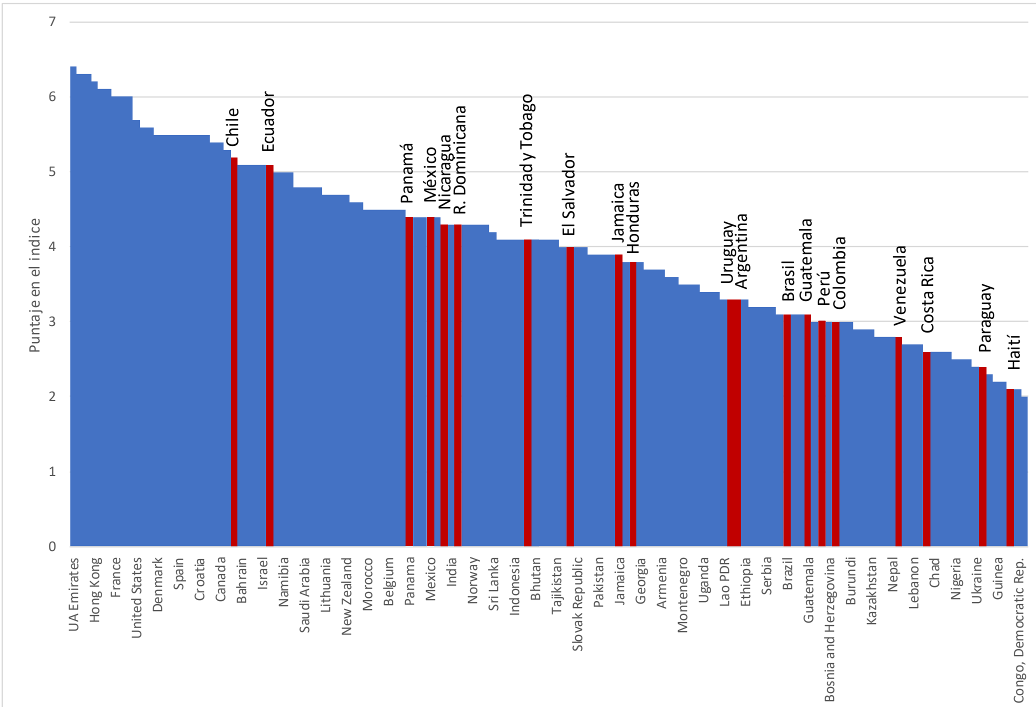
Source: Prepared by the authors based on data from FAOSTAT, 2019 and Frenken & Gillet, 2012.
Note: The irrigation needs index was calculated by taking the irrigation water requirement (calculated by Frenken and Gillet, 2012), stated in km^3/year, and dividing it by the farmed area to obtain an annual irrigation water requirement (km^3) for every km^2 of farmed area. Then, that requirement was multiplied by the non-irrigated portion of the farmed area. The Frenken and Gillet (2012) calculation takes into account the evapotranspiration of the countries' principal crops over the course of the year, the precipitation patterns, and the water extraction for irrigation.

Figure 8. Road density and land area, circa 2005



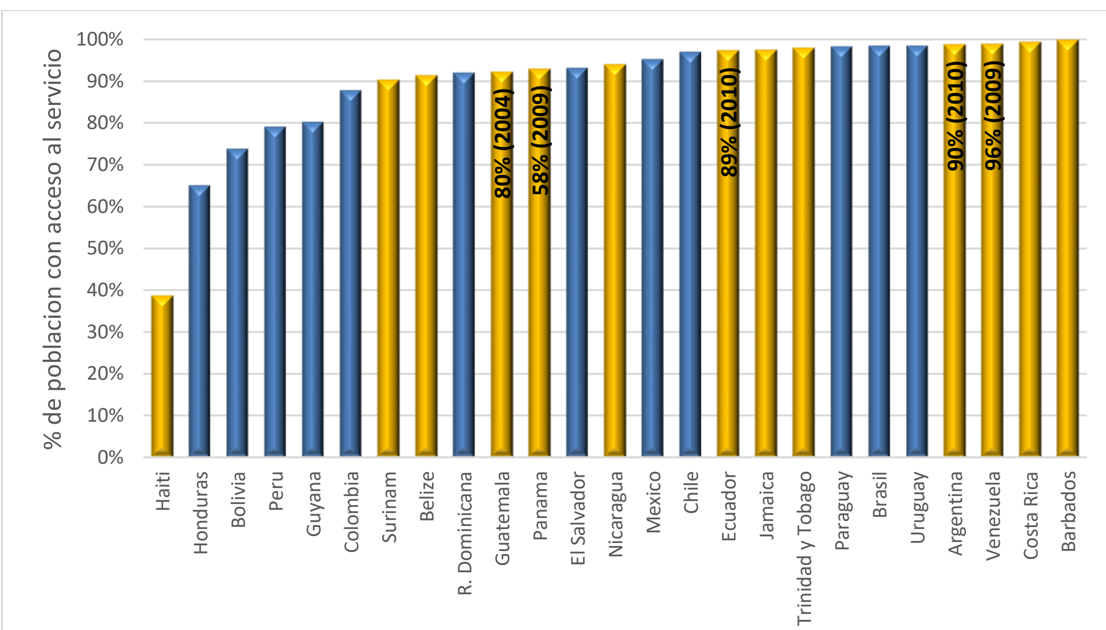
Source: Prepared by the authors using data from www.nationmaster.com

Figure 9. Perceived quality of roads



Source: Prepared by the authors based on data from the Global Competitiveness Index 2017-2018.

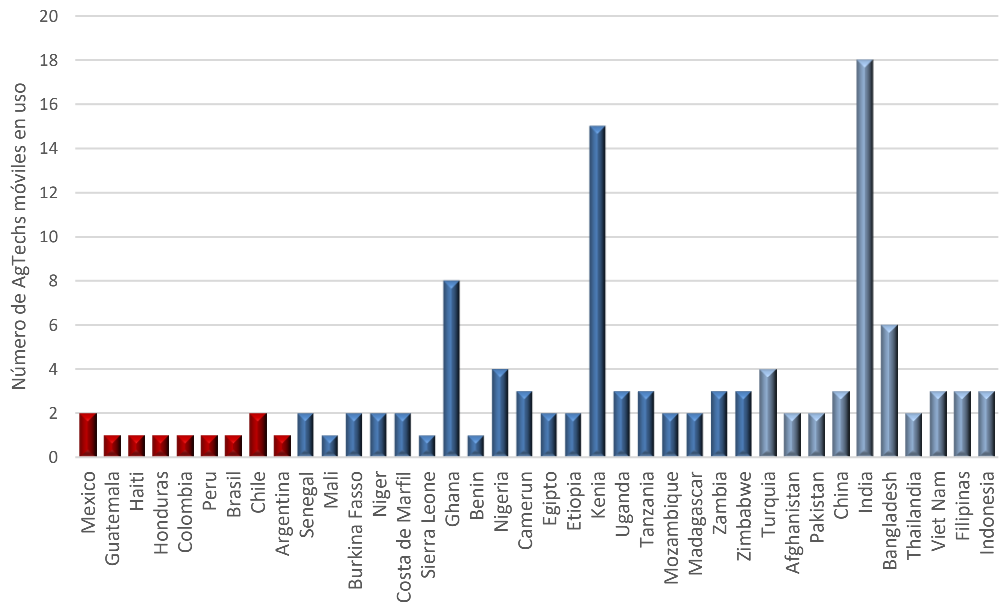
Figure 10. Access to electricity in 2017, percentage of the rural population



Source: Prepared by the authors based on data from sieLAC-OLADE, 2019.

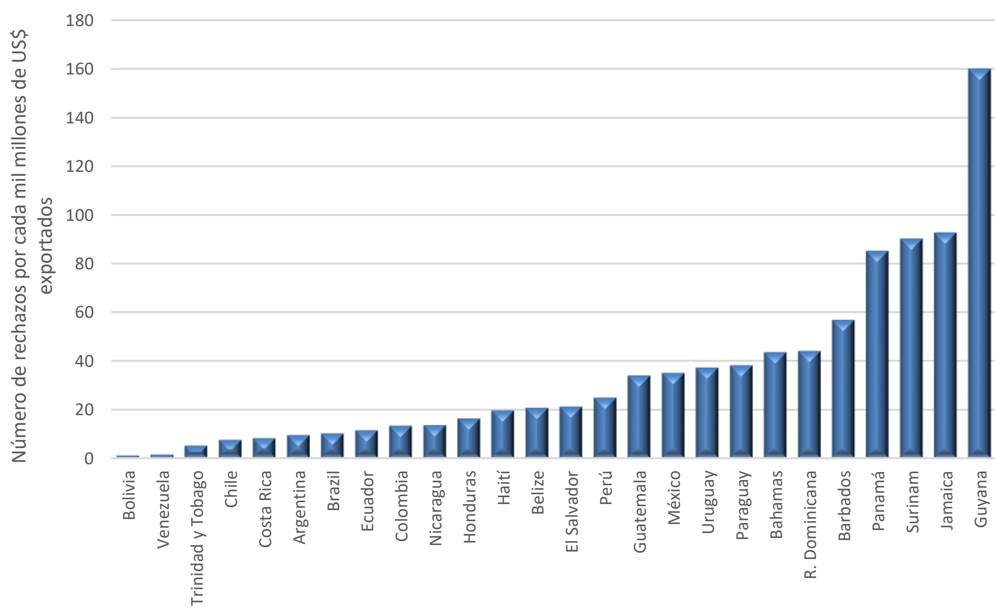
Notes: The figures for Honduras and Colombia are for 2016. The blue bars represent rural coverage and the yellow bars represent total (urban and rural) coverage. The figures inside the bars show the most recent available rural coverage figure in cases in which there is any.

Figure 11. Use of mobile agtechs in developing countries, 2019



Source: Prepared by the authors with data from GSMA AgriTech Deployment Tracker, available at https://www.gsma.com/mobilefordevelopment/m4d-tracker/magri-deployment-tracker/

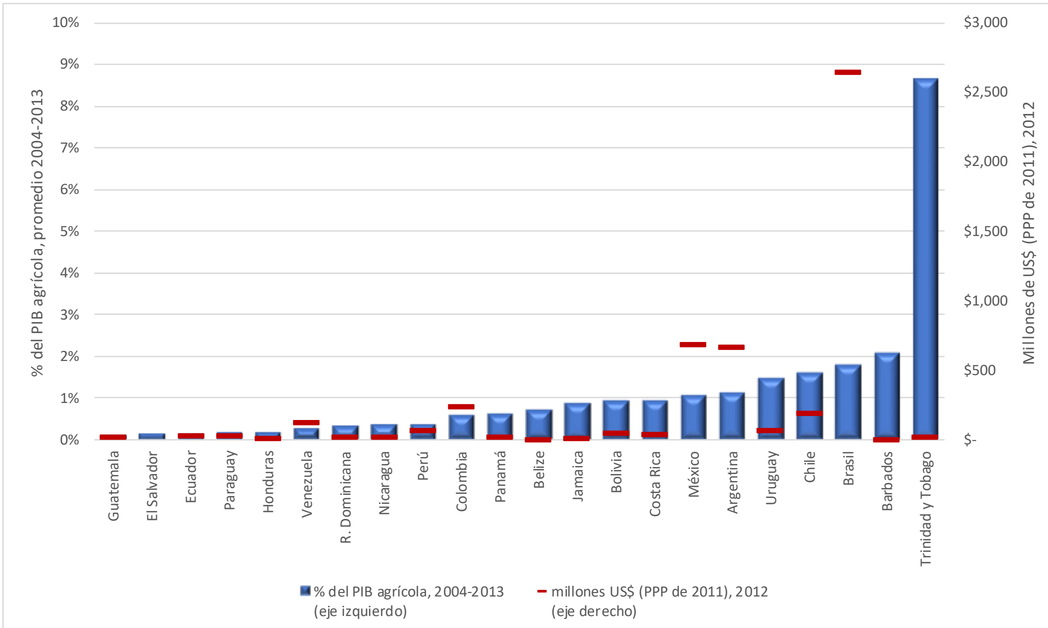
Figure 12. United States health-based rejections of food exports from LAC, weighted by export volume, 2010-2017 average



Source: Prepared by the authors based on data on U.S. FDA rejections and trade data from Comtrade.

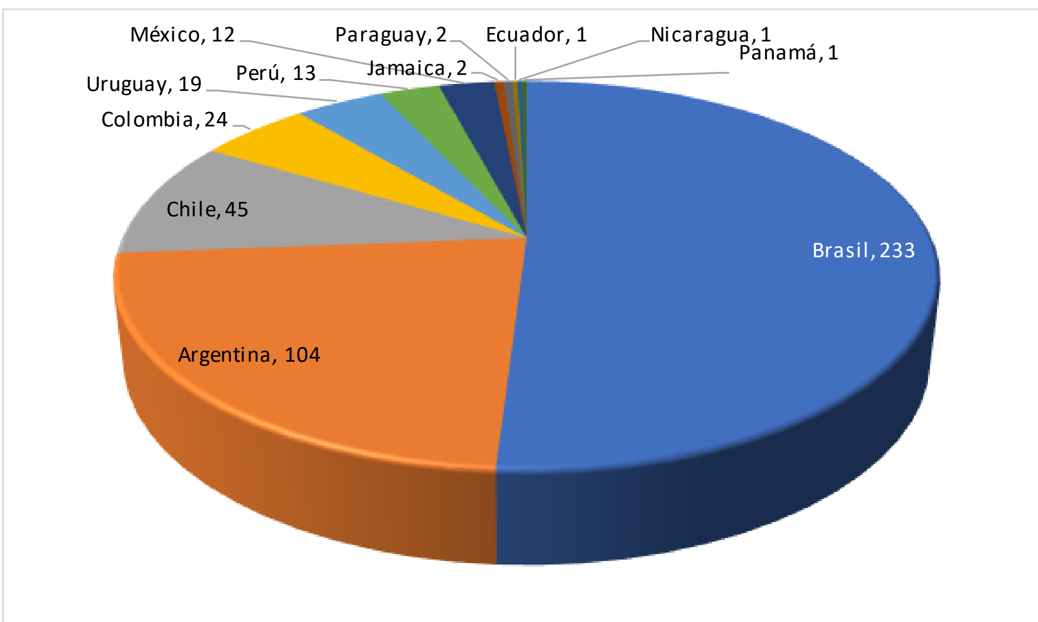
Note: This indicator is skewed toward zero in the case of countries that have closed markets for health reasons (and therefore do not experience rejections).

Figure 13. Public investment in R&D in LAC, 2004-2013



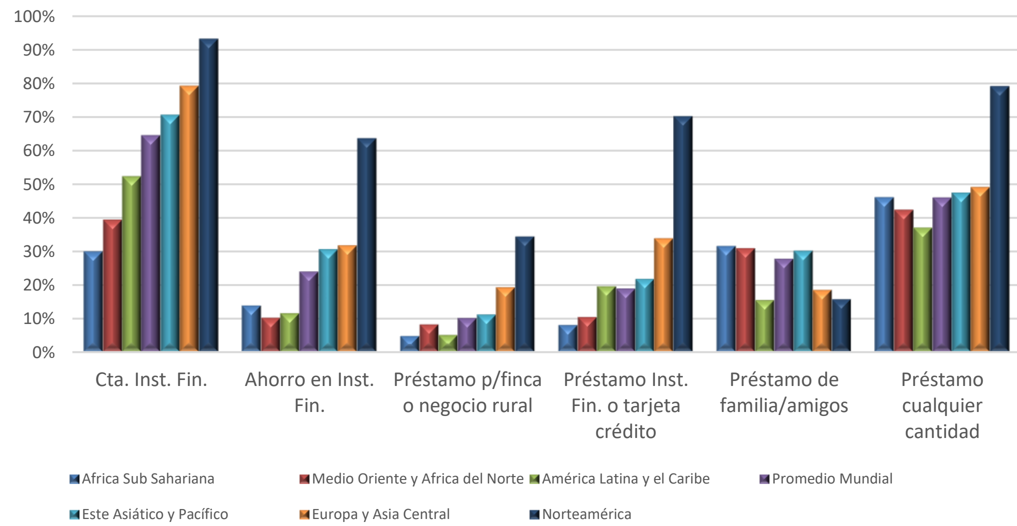
Source: Prepared by the authors based on data from ASTI (http://www.asti.cgiar.org/).

Figure 14. Number of agtech startups developed in LAC



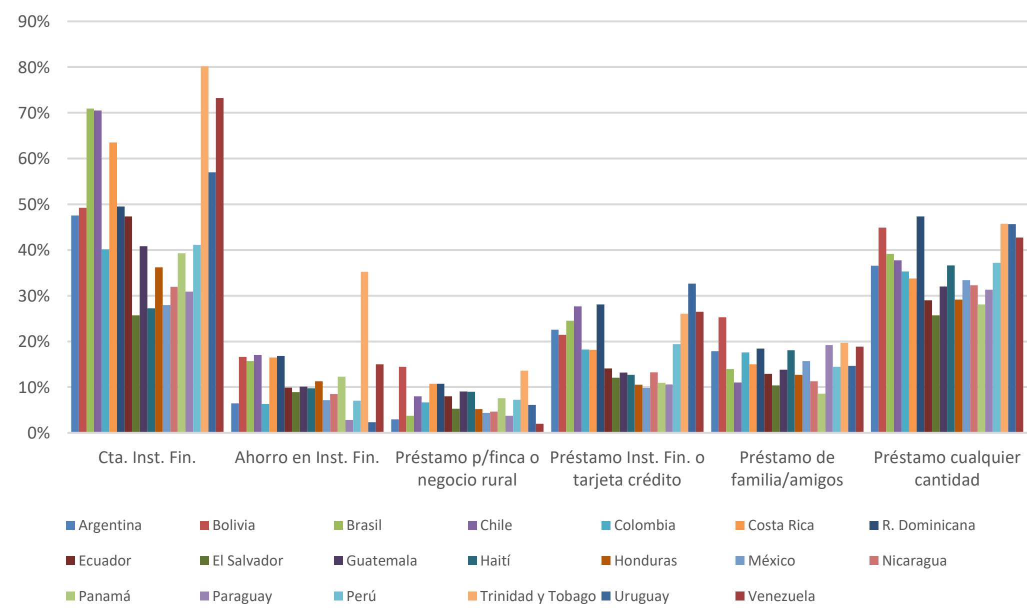
Source: Prepared by the authors based on data from IDB Lab, 2019.

Figure 15. Global financial access, rural population aged 15 or older, 2017



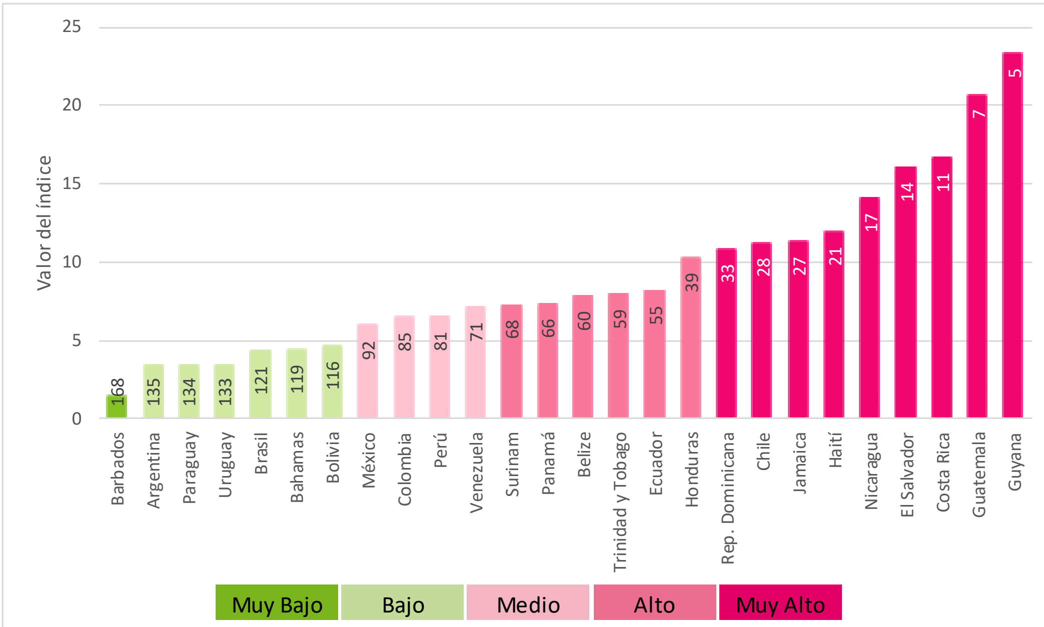
Source: Prepared by the authors using data from Global Findex (https://globalfindex.worldbank.org/).

Figure 16. Financial access in LAC, rural population aged 15 or older, 2017



Source: Prepared by the authors using data from Global Findex (https://globalfindex.worldbank.org/).

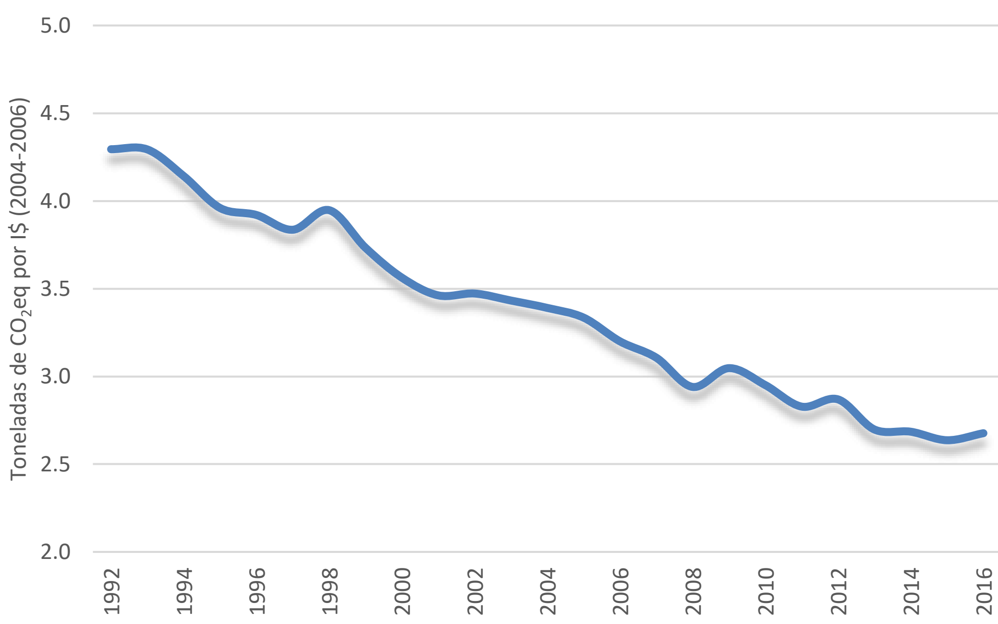
Figure 17. Global Risk Index, 2018



Source: Prepared by the authors using data from Heintze et al., 2018).

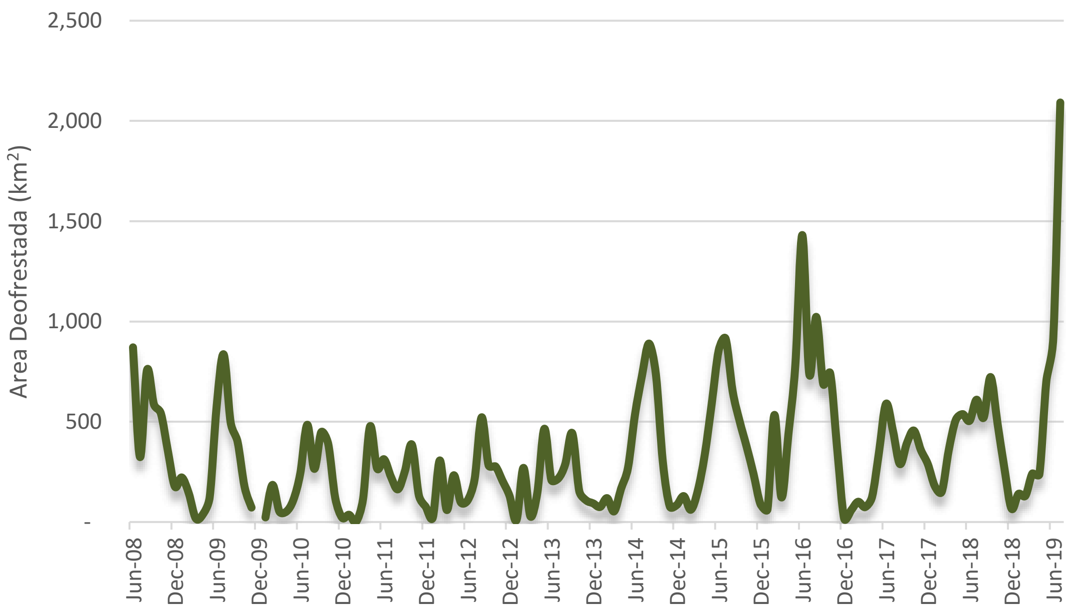
Note: The figures in the columns show where each country is ranked in relation to the 172 countries included in the index.

Figure 18. GHG emissions per unit of agricultural output, LAC



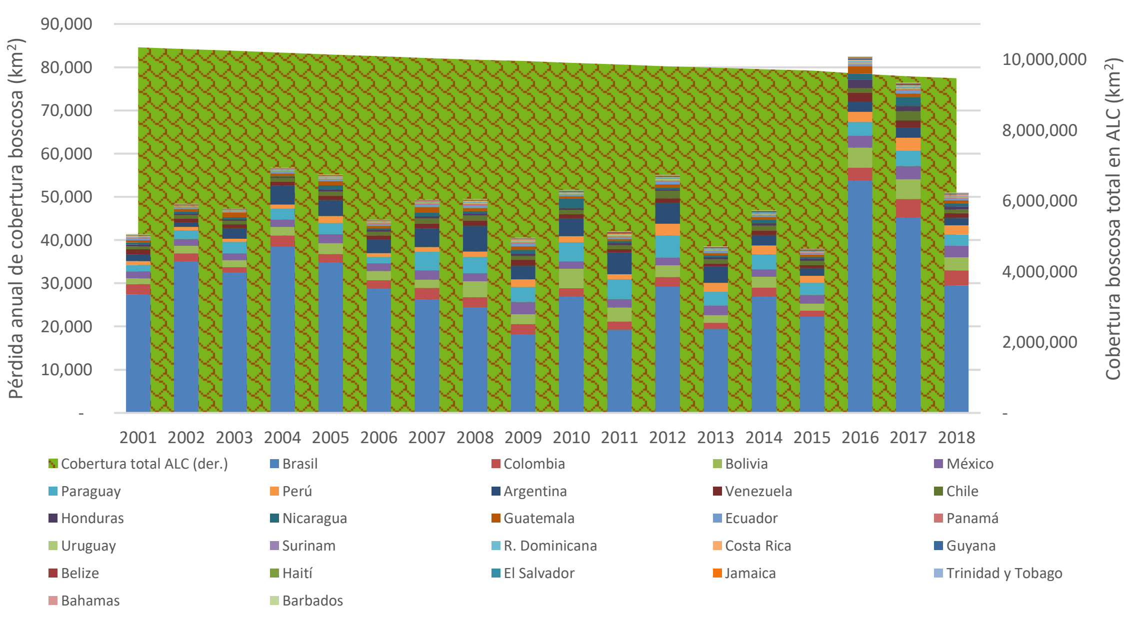
Source: Nin-Pratt, 2019.

Figure 19. Deforestation in the Brazilian Amazon



Source: Prepared by the authors using data from https://rainforests.mongabay.com/amazon/deforestation-rate.html, taken from the Instituto Nacional de Pesquisas Espaciais [National Space Research Institute].

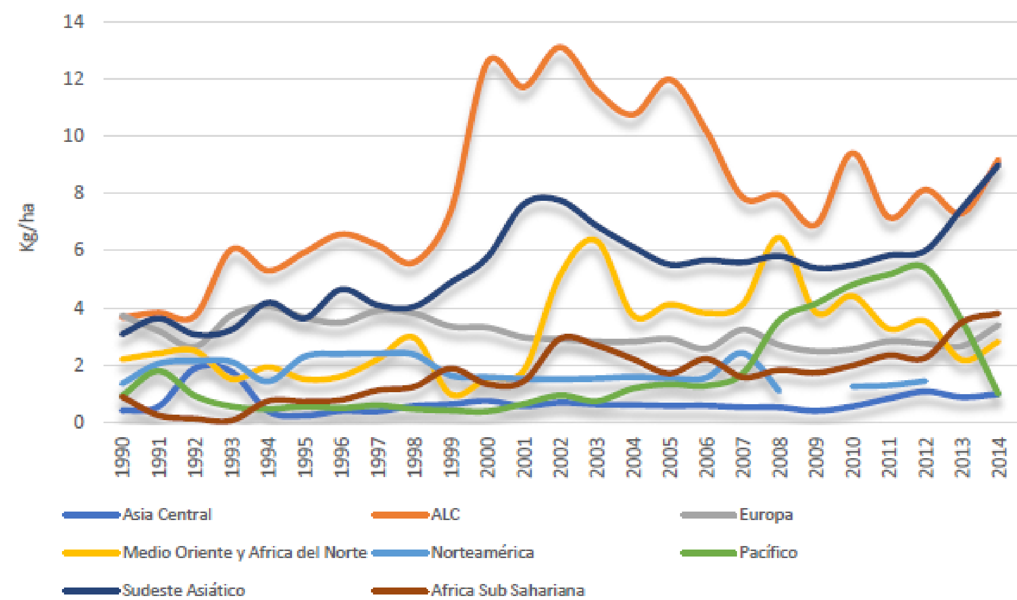
Figure 20. Loss of forest coverage in LAC, 2001-2018



Source: Prepared by the authors based on data from http://globalforestwatch.org/, obtained using the Hansen et al. methodology, 2013.

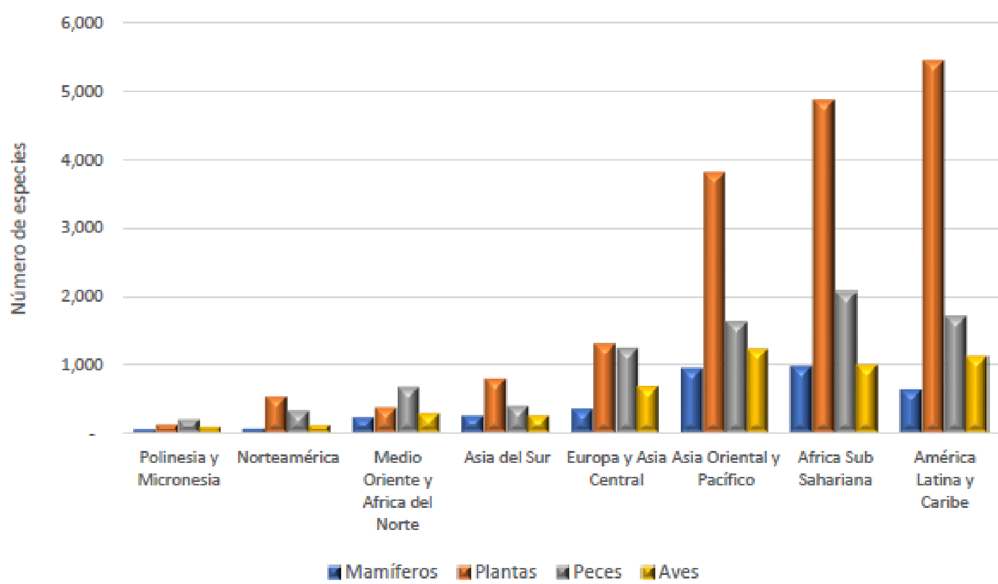
Notes: The data are taken from satellite images. A forest area is defined as an area in which the tree canopy covers at least 30% of the surface. The loss of forest cover includes all of its causes, such as deforestation and fires. The increase in forest cover loss in Brazil in 2016 and 2017 is primarily due to historic fires in the Amazon.

Figure 21. Use of pesticides in the world, 1990-2014



Source: Prepared by the authors using data from FAOSTAT, 2019.

Figure 22. Number of threatened plant and animal species by world region



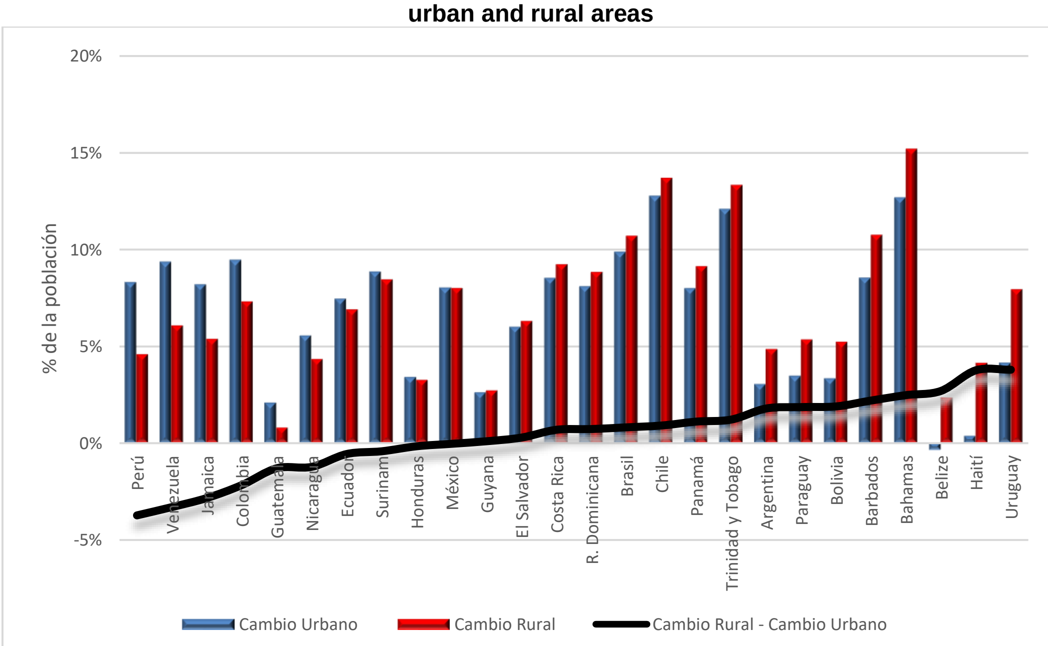
Source: Prepared by the authors using data from the World Bank, 2019.

Table 1. Rural poverty in Latin America and the Caribbean

Pobreza rural en países de ALC	Ca. 2000		Ca. 2014	
	Año	%	Año	%
Uruguay	2007	13	2014	2
Chile	1990	39	2013	7
Costa Rica	1990	27	2014	22
Ecuador	2000	66	2014	27
Brasil	1990	71	2014	29
Panamá	2001	55	2014	41
Colombia	1991	61	2014	42
R. Dominicana	2002	56	2014	44
México	1989	57	2014	45
Perú	1997	73	2014	46
El Salvador	1995	64	2014	49
Paraguay	1999	70	2014	51
Bolivia	1997	79	2013	54
Nicaragua	1993	83	2009	65
Guatemala	1989	78	2014	77
Honduras	1990	88	2013	82

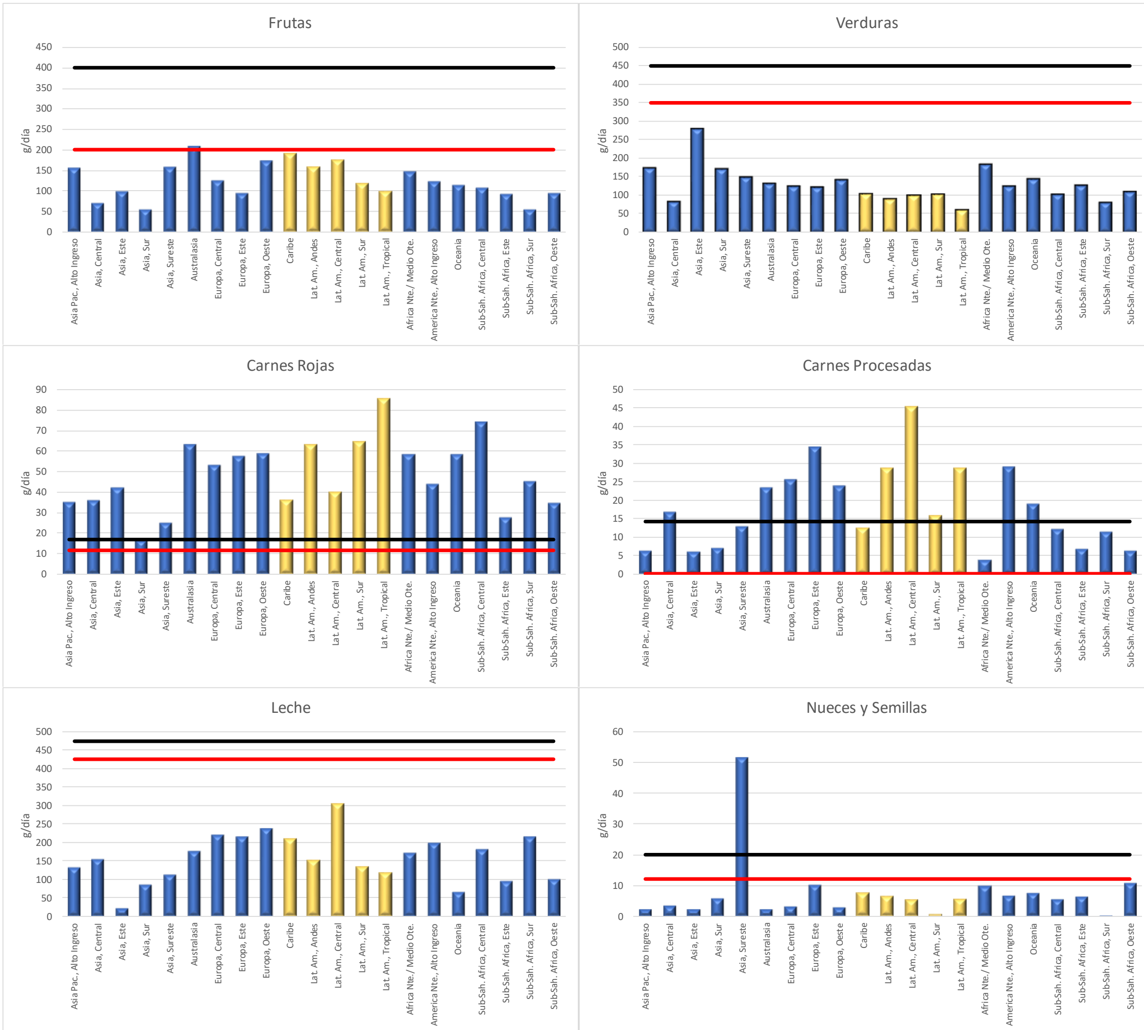
Source: FAO, 2018b.

Figure 23. 1980-2015 change in the percentage of the population aged 50 or older in LAC, urban and rural areas



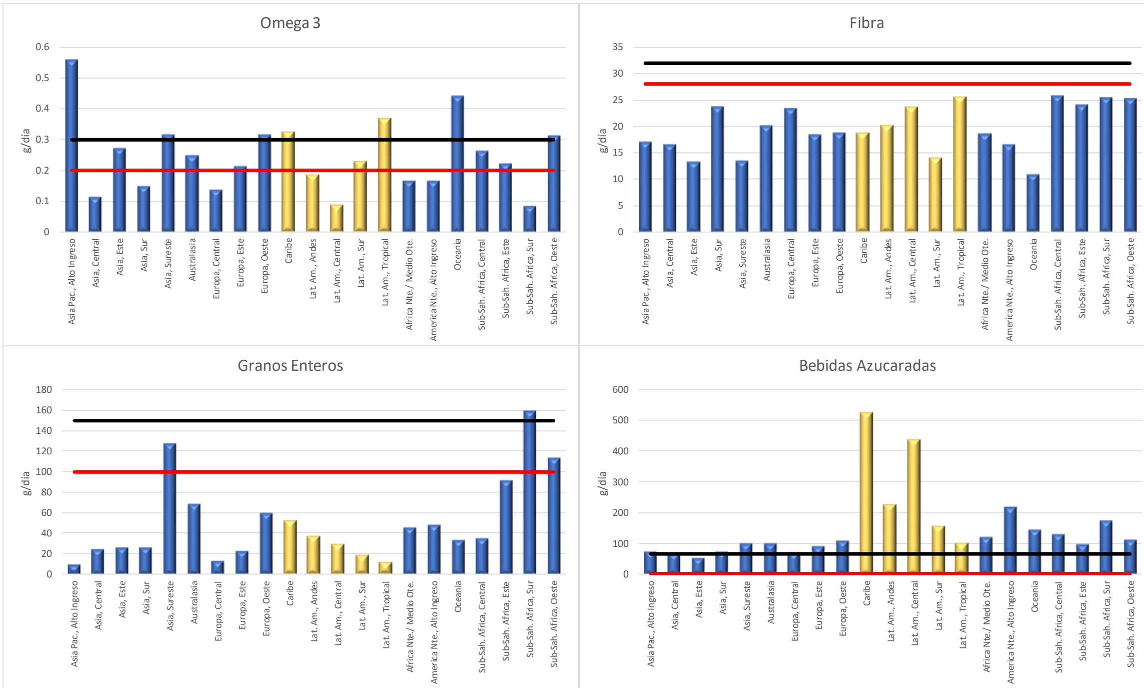
Source: Prepared by the authors based on data from the UN Population Division, “Urban and Rural Population by Age and Sex, 1980-2015,” version 3, August 2014.

Figure 24. World food consumption (2010) and recommended limits



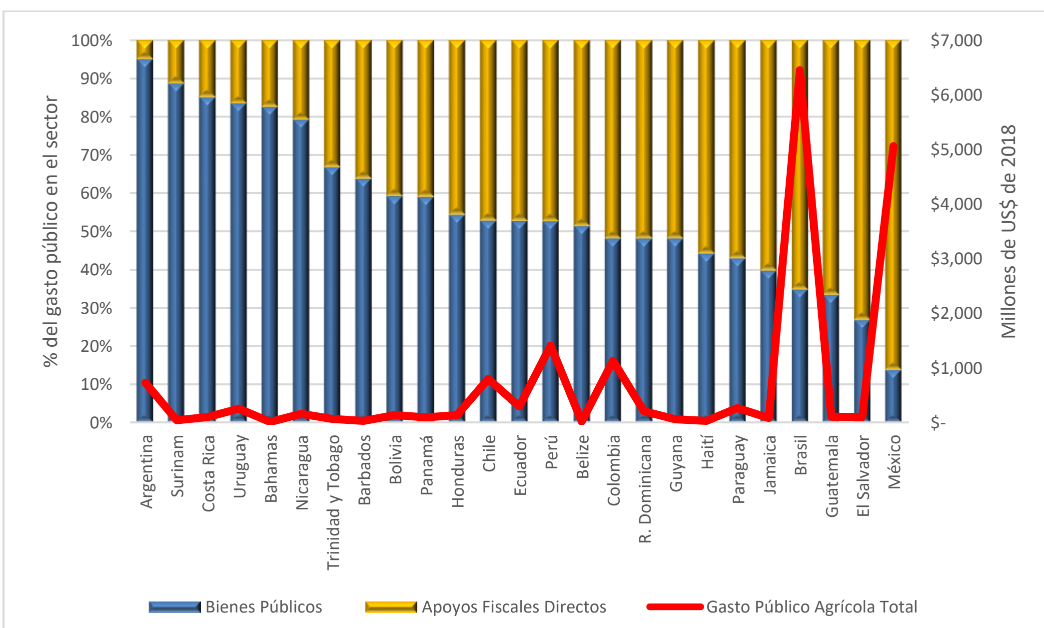
Note: The black line represents the recommended maximum intake and the red line represents the recommended minimum intake.

Figure 24 (cont'd.). World food consumption (2010) and recommended limits



Source: Prepared by the authors with data from www.globaldietarydatabase.org and limits established by the Global Panel on Agriculture and Food Systems for Nutrition, 2016a.
Note: The black line represents the recommended maximum intake and the red line represents the recommended minimum intake. The Omega 3 intake was calculated assuming that each gram of fish and seafood intake contains 10mg of Omega 3, based on the average minimum content of Omega 3 in salmon (17,647mg) and the maximum content of Omega 3 in scallops (2,353mg).

Figure 25. Breakdown of agricultural public spending in LAC



Source: Prepared by the authors using data from Agrimonitor.
Note: The data are for different years ranging from 2014 to 2017, except in the cases of Bolivia (2009) and Peru (2013).

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