NEW HORIZONS FOR PRODUCTIVE TRANSFORMATION IN THE ANDEAN REGION

EMBRACING AGRICULTURE TO ACHIEVE PRODUCTIVE DIVERSIFICATION

GROWTH AND PRODUCTIVE TRANSFORMATION AGENDA

IDB

EMBRACING AGRICULTURE TO ACHIEVE PRODUCTIVE DIVERSIFICATION

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CREDITS

This publication is part of a collection of works carried out by the Inter-American Development Bank to support policy dialogue on productive transition in the Andean countries. It was edited by Liliana Castilleja-Vargas and Priscilla Gutiérrez Juárez.

We are grateful to Francisco Alpízar (Wageningen University and Research) for his advice. The contributions to each chapter are detailed below:

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FOREWORD

We highlighted in our first book in this series on growth and productive transformation that the Andean region is at a time when sound decision making is essential and indispensable. Following the Paris Agreement, the world has launched a decarbonization agenda; implementation challenges may exist, but the world has decided to move in this direction. The region faces great challenges, but also a potential for opportunities.

In addition to this reality, there are the consequences of the pandemic. Beyond the high costs in terms of loss of human life and economic activity, the pandemic has impacted our region in a structural way. All of these challenges come at a particular time. After growing at an average of 4.2% between 2000 and 2014, growth has slowed in the Andean region. The long-term growth outlook is 2.9%, according to the International Monetary Fund.

Within this context, the agricultural sector can play a key role. The sector grew in the Andean countries during the pandemic, and even when it did not grow, its decline was less than the rest of the economy, increasing its share in the gross domestic product. Therefore, it is a sector with enormous potential and should be the essential engine of the productive transformation that the Andean region must undertake.

Agriculture represents both the traditional and the modern at the same time. Historically, crops such as coffee, cotton, bananas and cocoa have been part of the region's export portfolio. However, the sector has also developed new niche markets with potential, such as blueberries, quinoa and avocado. Even crops such as coffee have been adapting to become examples of modernization in traditional sectors.

The sector faces major institutional challenges, which hinder market access: low productivity, slow progress in the development of agrotechnology, low associativity, and the impacts of climate change, among others. Moreover, given that rural poverty is higher than urban poverty in the region, this has a considerable social impact. As a result, issues such as property ownership have not yet been fully resolved.

However, as demonstrated by new export products, these challenges can be overcome. To achieve this, collaboration between State and producers is essential. However, this collaboration does not end here; the academic world, the financial sector and other actors play a key role in advancing an agenda for the transformation of the agricultural sector. It is therefore essential to consider how to address this structural change that is taking place in the world and its impact on agriculture in the region.

This report by the Department of the Andean Group of the Inter-American Development Bank (IDB) seeks to contribute ideas for this approach. The purpose of this publication is not to provide an exhaustive review of how to deal with the transition. IDB has been making some recommendations on policy decisions to be taken in the sector. In addition, some think tanks in the region have also been formulating proposals on the path of this transformation. Accordingly, the purpose of this research is to complement these proposals.

This publication analyzes areas that can influence the performance of the sector, as well as some specific subsectors that allow us to understand how all these areas are integrated in specific cases.

The aim is to make a proposal to generate opportunities in this sector. Thus, the topics of infrastructure, climate change and institutions are addressed.

The cases of different subsectors, such as forestry, superfoods and agrotechnology, are also presented in detail. Finally, to have a productive transition agenda is to propose an employment agenda. However, it is important to emphasize that employment must be inclusive; therefore, gender issues are an essential part of this research.

We hope that this will be a source of discussion on the role of agriculture in the productive transition, and that it will complement the Bank's commitment to assist our member countries and collaborate with them to achieve this shared goal.

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Acting Interim General Manager
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1. INTRODUCTION

COMMITTING TO AGRICULTURE IS A WINNING CHOICE

A millenary activity has shaped the way of life of Andean communities. Not only because of its importance for the food security of the population, but also because of its potential to contribute to more inclusive and sustainable growth. Agriculture has played a key role in the economic and social development of the countries of the Andean region.

Between 2012 and 2021, the agricultural sector has reported, on average, 12.6%, 9.2%, 6.2% and 5.7% of GDP in Bolivia, Ecuador, Colombia and Peru, respectively, and currently accounts for 29.7%, 27.5%, 16.7% and 27.8% of total formal employment.[1] Moreover, the agricultural sector offers unique opportunities to contribute to the ambitious climate goals that countries have set in recent years, through a production model that can contribute to reducing carbon emissions generated by the activity and addressing troubling issues such as accelerated deforestation and the efficient use of water resources. To make these benefits a reality, it is necessary to address long-standing structural challenges related to the low productivity of the sector, which exhibits poor or even negative levels over certain time periods. What factors are underlying the low agricultural productivity in the Andean region? This publication examines the main bottlenecks, such as the limited multimodal infrastructure supporting the sector and the institutional aspects that affect the expansion and competitiveness of this activity. Along these lines, this analysis also provides estimates of the costs required to provide such infrastructure - road, energy and irrigation- and their impact on the sector's productivity. The results indicate that the

benefits far outweigh the costs.

Another underlying aspect that determines key aspects for achieving sustained, inclusive and environmentally friendly productive development is the institutional framework supporting agriculture. Its structure, approach and support mechanisms set the standard for aspects ranging from the provision of public goods by the State, public-private coordination, the type of institutional structure and the way in which the various public agencies operate. Although each Andean country has its own specificities regarding their institutional framework, with its advantages and room for improvement, a common characteristic is the vertical structure made up of ministries and agencies that usually operate in silos, with little or no articulation and coordination. Undoubtedly, better coordination among the ministries of agriculture and a more efficient targeting of public policies and support instruments would lay the foundations for boosting the development of the sector, its integration into agroindustrial chains and its successful participation in international markets.

1 Based on our own calculations using information from employment data by economic activity from ILO (https://ilostat.ilo.org/ topics/employment/).

While it is important to understand the challenges that restrict the potential of agriculture, it is even more crucial to identify the opportunities that the sector has to offer. A sustainable agricultural production model that is resilient to the impacts of climate change emerges as the key to contributing to the decarbonization goals of countries. From crop diversification to improved water use, this book offers public policy recommendations for countries to harness agriculture as an engine for climate change adaptation and mitigation.

The agricultural sector offers opportunities for a large number of people. It is particularly important to emphasize that women are very important actors in this sector. However, they have limited economic autonomy, which is reinforced by their low level of schooling, as they have a low rate of land ownership, less access to financing and, in general, lower income from this activity than men. Throughout these pages, opportunities are discussed to increase the inclusion of women farmers and contribute to their empowerment and development. Another opportunity that emerges is economic diversification and the positioning of Andean agricultural products in niche and high value-added markets. Beyond the traditional products, countries in the region have the potential to diversify and sophisticate their agricultural portfolio and optimize their marketing in international and local markets. Products with high nutritional content, such as superfoods and more sustainable forestry and livestock production are emerging as potential opportunities for the sector. A menu of productive options is offered for the region to gain more exposure and greater relevance in international markets, where these products are highly valued.

Connecting the agricultural sector with new economic opportunities is one of the major public policy objectives of the countries in the region. In this respect, an opportunity exists in the Andean countries to achieve more effective, inclusive and fruitful links to value chains. The benefits that can be derived from

developing such links are great: from improving the productivity of the sector, creating jobs, boosting the export sector and its impact on the balance of payments, to generating prosperity, well-being and quality of life for the population, particularly in rural areas.

A unique asset of this region is the Amazon. Between 40% and 60% of the territory and forests of the Andean countries are within the great Amazon basin, which is rich in diversity of flora and fauna, and which, probably as a whole, is made up of the richest forests on the planet. Opportunities for sustainable growth and diversification in the Amazon Forest sector are extensive. However, multiple challenges must be overcome in order to harness and catapult this potential. This publication provides an overview of opportunities to exploit, in a sustainable and socially responsible manner, the full potential that the forestry sector offers to the economies of the region.

Technology cannot be left out of this analysis. With this in mind, we explore the emergence of new players in the agricultural ecosystem that use technology in their business models as an ally to solve problems associated with the sector's low productivity. Andean Agtechs are here to stay. Using disruptive technology such as blockchain, big data and artificial intelligence, these ventures are beginning to make their mark in the agricultural sector. This study presents the first mapping of Agtechs in the region and provides an overview of the main challenges and opportunities posed by these new players. Through case studies, it documents the opportunities that are already being seized by the sector, although there is still a long way to go.

Betting on agriculture is a win-win strategy. The sector has shown its resilience and potential to contribute to the economy, despite disruptions such as the COVID-19 pandemic. Its importance in the lives of millions of people, particularly in rural areas and remote territories, is undeniable, with direct implications on poverty and the living conditions of most of the population. Solving the challenges facing the sector is strategic, as the benefits far outweigh the costs. It is time to take action and reap the benefits for all.

2

INFRASTRUCTURE

2. CLOSING INFRASTRUCTURE GAPS IS A MUST TO BOOST PRODUCTIVITY IN THE AGRICULTURAL SECTOR

2.1 Introduction

Much has been written on the agricultural sector's productivity determining factors. Not only because of the impact that low productivity has on the activity's own returns and competitivity, but also because of the high social and economic costs it imposes. The agricultural sector faces challenges in adapting to an ever-changing environment, which requires maximizing production and achieving environmental sustainability at the same time, streamlining institutional processes to reduce competitiveness-related costs, and seeking new opportunities on a daily basis. To this end, the role of infrastructure is paramount. Investment in energy, roads and irrigation has a positive impact on agricultural production in the Andean countries. Investing in these areas will make it possible to continue increasing the technical efficiency of the sector, improving its competitiveness and the quality of life of people engaged in agriculture.

Using stochastic frontier analysis, agricultural TFP (total factor productivity) was estimated for the Andean countries from 1969 to 2016. The results indicate that the average variation in agricultural TFP for the Andean countries is 1.1% and for non-Andean countries, 1.7%. The Andean countries grew, on average (weighted), more slowly than the non-Andean countries as a group. A considerable reduction in TFP is identified for Ecuador and Venezuela during the period 2009- 2016, mainly driven by the economic challenges these countries faced during this period. The results are shown in Table 2.1:

Table 2.1. Average agricultural TFP in the Andean region countries (1969-2016).

Country	1969-1979	1980-1989	1990-1999	2000-2009	2010-2016
Bolivia	–0.071	0.612	1.584	–0.151	0.297
Colombia	1.555	1.481	0.748	0.893	2.536
Ecuador	1.608	2.222	2.772	1.978	–2.632
Peru	1.210	1.282	2.196	2.399	1.592
Venezuela	1.716	1.704	1.747	1.528	1.203

Source: Neves *et al.* (2021)..

Several factors that directly affect the technical efficiency of the agricultural sector are identified in the literature. Trindade and Fulginiti (2015) show that irrigation, trade openness, GDP per capita, education and health (life expectancy) explain the technical inefficiency of the sector. Thus, while trade openness and GDP per capita increase this, irrigation, education and health decrease it.

In addition to these variables, road density (kilometers per square kilometer) emerges as a determinant of sector productivity. Road networks are a key component of agricultural production and distribution. Colombia, Peru, Ecuador and Bolivia have low road density compared to developed countries, which implies a considerably high transportation cost and limits their competitiveness in the international agricultural market. Average travel times to centers with 50,000 or more inhabitants range from 2.5 hours in Ecuador to 4 hours in Peru, but in some parts of Colombia, road travel can take up to 90 hours.

Exhibit 2.1.

Total Factor Productivity (TFP)

According to Lora and Pagés (2011), TFP is a measure of productivity that is generally obtained as the quotient between the total good produced by an economy and the production factors (capital, labor and human skills).

Stochastic frontier

In theory, a production frontier function expresses the maximum quantity of output obtained from a given quantity of inputs and fixed technology. The work of Aigner *et al.* (1976) proposes a new approach to estimate it, called 'estimation of stochastic frontier production function models'. Within this framework, Neves *et al.* (2021) employ this methodology to calculate changes in productivity (changes in TFP), as the sum of: (i) technical change, which comes from changes in the efficiency of input use, and (ii) change in technological efficiency, which represents the speed at which a country moves away from or towards the production frontier.

On the other hand, access to energy (electricity) has an unequivocally positive effect on agricultural production. Overall, access to electricity (measured in kWh per capita) is correlated with higher agricultural production and is positively related to rural extension services and credit, but is negatively associated with proximity to cities of 50,000 inhabitants or more (or population densities of 1.5). Lack of access to energy sources can also restrict farmers' ability to access information or use better inputs. For example, less than 8.5% of farmers in Bolivia used electricity for agricultural production, while 54.5% used firewood.

Agricultural technical efficiency is estimated using a stochastic production function to assess whether road infrastructure and access to energy help decrease agricultural technical inefficiency at the most possible granular level, i.e., at the farm level. The results suggest that road density and travel time affect agricultural efficiency in all four countries. Increases in road density decrease agricultural technical inefficiency for Bolivia, Peru and Ecuador, substantiating the hypothesis that the availability of the road networks can help farmers make better use of inputs for production. On the other hand, farmers who take longer to reach large cities have higher technical inefficiency in Bolivia, Peru and Ecuador. Technical efficiency (inefficiency) decreases (increases) as farms are further away from cities with more than 50,000 inhabitants or 1,500 inhabitants per km2. Findings also suggest that farmers who used specific energy sources have lower inefficiency. Access to energy in agricultural activities has the potential to raise the value of production by up to 29%.

Several studies suggest that access to irrigation is also associated with higher agricultural production. This technology has been widely studied as a way to increase production to meet growing global demand;

however, its adoption is costly for growers. In Bolivia, 32% of producers use irrigation for production; however, this only translates into 7% of the planted area being irrigated. In Colombia, the percentage of farms with irrigation is higher, reaching 33.3%. The proportion of Ecuadorian growers adopting irrigation is 31%, although this number does not represent the full irrigation potential in the Andean region. This is also the situation for Peru, where 21% of small farmers and 52% of large farmers have adopted irrigation (Neves *et al.*, 2021).

In Colombia, a 10% increase in irrigated area led to a 3.3% increase in production, all else being equal; the department of Norte de Santander, in particular, shows a 4.6% increase due to a 10% expansion in irrigated area. In Bolivia, a 10% increase in irrigated land leads to a 4.00% increase in production, and the department of Santa Cruz shows the greatest potential to increase production: 0.9%. In Ecuador, a 1% increase in agricultural production is found as a result of a 10% increase in irrigated land: the department of Morona Santiago shows a 4.6% response to increased adoption. Finally, agricultural production in Peru responds to a 10% increase in irrigated area with an improvement of 7.00%. The Peruvian department of San Martin had the highest response in production, namely 2.3%.

In summary, investment in energy, roads and irrigation has positive impacts on agricultural production in the Andean countries. Investing in these areas will make it possible to continue increasing the sector´s technical efficiency and its competitiveness, as well as improving the quality of life of people who are engaged in agriculture.

Table 2.2. Impact of investment in energy and irrigation on agricultural production

Country/sector	Energy	Irrigation
Bolivia	28.85%	4.00%
Colombia	8.15%	3.30%
Ecuador*	16.44%	10.00%
Peru	12.33%	7.00%

Source: Neves *et al.* (2021).

Notes: * Energy for Ecuador is the average of the other three countries, as there is no information available.

2.2 Increasing investment in the agricultural sector poses challenges

The agricultural sector was among the few contributors to economic growth during the COVID-19 crisis. While sectors such as construction, tourism and manufacturing, which traditionally play major roles in the growth of the region's economies, declined at unprecedented rates, agriculture, in turn, was among the sectors that contributed to economic growth.

Given the region's complex fiscal outlook, particularly in the post-pandemic context, finding budgetary room to allocate resources for this sector is a task that requires prioritizing those projects with the highest expected returns. To this end, it is important to have an estimate of costs involved in addressing the infrastructure gaps explained above. Through the identification of the main infrastructure projects at the sector level and by calculating the unit costs per sector, the cost-benefit[1] of closing the infrastructure gaps in the sectors mentioned above (roads, energy and irrigation)[2] was calculated:

Table 2.3. Unit costs

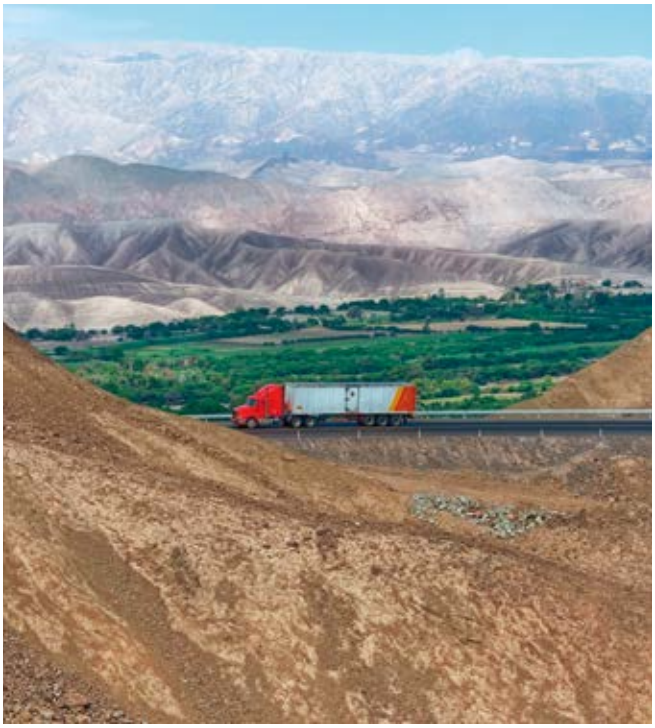
Sector	Unit costs	Amount (USD)			
		Bolivia	Colombia	Ecuador	Peru
Energy	Per connection	948	723	n.d.	542
Gravel/ basic pavement	Per Km	37,000/695,000	37,000/695,000	37,000/695,000	37,000/695,000
Irrigation	Per hectare	1,375.75	1,499.94	1,683.49	2,225.13

Source: Bonifaz (to be published soon).

1 See Annex 2.1 for more details of the theoretical framework of the cost-benefit model used.

2 It should be noted that there are certain factors that may affect the reliability of the estimate. First, investment needs assume that investment is carried out efficiently; however, recent IDB estimates (Cavallo *et al.*, 2020) indicate that inefficiency costs in the execution of infrastructure projects and avoidable delays can increase investment needs by as much as 35%. Second, estimates are based strongly on investments linked to the construction of infrastructure; however, as highlighted in DIA 2020, there are regulatory interventions needed to improve the delivery of services that exceed the construction of infrastructure; these types of investments may be cost-effective, particularly in the context of exiting the COVID-19 pandemic (Cavallo *et al.*, 2020). A third factor has to do with unit costs. Each investment project has its own characteristics that depend on geography, the idiosyncrasies of the country and the technology to be used. However, the unit costs used correspond to averages and, consequently, are approximations to the actual costs of the investment project. Fourth, other needed investments are not considered, the estimation of which requires a more detailed analysis of the particular conditions at country level, and even at city level. Finally, estimates were made regarding investment and maintenance needs using available information, and reasonable estimates could be made regarding the existing infrastructure inventory. In some sectors, the estimates made correspond to minimum essential amounts and, therefore, the requirements could be higher than the estimates.

To estimate the impact of the road network, travel times from each farm to a population center with more than 50,000 inhabitants were selected. For each road to be built, a cost per km was applied: USD 37,000 in the case of gravel and/or USD 695,000 in the case of pavement, plus their respective regular maintenance costs. To calculate the benefit, the percentage impact was applied to the value of current production of farms with no roads. This estimate shows that it is profitable only in the cases of Colombia and Ecuador to propose basic pavement solutions, although in Ecuador, the proposed solution is a gravel road. In contrast, investments in roads in Peru exceed the net value of productivity, so it would not be profitable to invest in roads exclusively to improve agricultural productivity.



- In **Bolivia**, providing roads to all farms in the country generates a cost of USD 926 million for gravel and USD 17,405 million for pavement. The additional benefit amounts to USD 4,726 million. The benefit-cost analysis is USD 3.799 million measured on the basis of net production income value (NPIV) in the case of gravel and USD -12.679 million in the case of pavement. The return on investment is 410% in the case of gravel and negative in the case of pavement. A 44.9% impact of the road on the sector's productivity has been estimated.

- In **Colombia**, providing roads to all farms in the country results in a cost of USD 3,738 million in the case of the pavement solution. The additional benefit is USD 22,171 million measured on the NPIV. The return on investment is 493%. A 54.33% impact of the road on the sector's productivity has been estimated.

- In **Ecuador**, providing roads to all farms in the country generates a cost of USD 35 million in the case of gravel and USD 665 million with pavement. The additional benefit is USD 3,073 million. The cost-benefit analysis measured on the NPIV is USD 3,038 million in the case of gravel and USD 2,408 million in the case of pavement. The return on investment is 86 times in the case of gravel and 3.6 times in the case of pavement. A 66.58% impact of the road on the sector's productivity has been estimated.

- In **Peru**, providing roads to all farms in the country generates a cost of USD 4.93 billion in the case of gravel. The additional benefit is USD 557 million measured on the NPIV in the case of gravel. The return on investment is negative. An impact of 44.90% of the road on the productivity of the sector has been estimated.

Table 2.4. General benefit-cost analysis. Roads (USD millons)

Country	Cost	Benefit (NPIV)	Benefit-cost
Bolivia (gravel/pavement)	926/17,405	4,726	3,799/-12,679
Colombia (pavement)	3,738	22,171	18,432
Ecuador (gravel/pavement)	35/665	3,073	3,038/2,408
Peru (gravel)	4,930	557	-4,372

Fuente: Bonifaz (de próxima publicación).

The impact of introducing electrical energy in the farms has a clearly positive profitability on agricultural production in all the analyzed countries. Farms without electrical energy were selected, and the number of households was identified based on the reported density in the farm, assigning a connection cost. As for the benefit, the percentage impact was applied to the current production value of the farms without electrical energy.

- In **Bolivia**, supplying electrical energy to all farms in the country incurs a cost of USD 308 million and provides an additional benefit of USD 1,167 million measured on the basis of NPIV. The return on investment is 278%, considering that the impact used is 28.85% of energy on the sector's productivity.

- In **Colombia**, supplying electrical energy to all farms in the country incurs a cost of USD 1,455 million and provides an additional benefit of USD 1,745 million measured on the basis of NPIV. The return on investment is 20%, considering that the impact used is 8.15% of energy on the sector's productivity.

- In **Peru**, supplying electrical energy to all farms in the sample incurs a cost of USD 14 million and provides an additional benefit of USD 49 million measured on the basis of NPIV. The return on investment is 242%, considering that the impact used is 12.33% of energy on the sector's productivity.

Table 2.5. General benefit-cost analysis. Energy (USD millons)

Country	Cost	Benefit (NPIV)	Benefit-cost
Bolivia	308	1,167	859
Colombia	1,455	1,745	290
Ecuador*	n.d.	n.d.	n.d.
Peru	14	49	34

Source: Bonifaz (to be published soon).

Regarding irrigation, the analysis was approached using two methodologies. In the first one, the increase in productivity over current production was calculated. Farms corresponding to non-irrigated areas were selected, and an irrigation cost per hectare was assigned. For the benefit, the percentage impact was applied to the current production value of non-irrigated farms.

- In **Bolivia**, irrigating the farms in the country that do not have irrigation incurs a cost of USD 3,318 million. The additional benefit of irrigating these areas is USD 715 million. The benefit-cost analysis is USD -2,603 million, and the return on investment is negative. A 4% impact of the irrigated farm on the sector's productivity was considered.

- In **Colombia**, irrigating the farms in the country that do not have irrigation incurs a cost of USD 18,122 million. The additional benefit of irrigating these areas is USD 1,097 million. The benefit-cost analysis is USD -17,025 million, and the return on investment is negative. A 3.3% impact of the irrigated farm on the sector's productivity was esttimated.

- In **Ecuador**, irrigating the farms in the country that do not have irrigation incurs a cost of USD 696 million. The additional benefit of irrigating these areas is USD 252 million. The benefit-cost analysis is USD -445 million, and the return on investment is negative. A 7% impact of the irrigated farm on the sector's productivity was estimated.

- In **Peru**, irrigating the farms in the country that do not have irrigation incurs a cost of USD 1,901 million. The additional benefit of irrigating these areas is USD 53 million. The benefit-cost analysis is USD -1,849 million, and the return on investment is negative. A 7% impact of the irrigated farm on the sector's productivity was considered.

Table 2.6. General benefit-cost analysis. Irrigation (USD millons)

Country	Cost	Benefit (NPIV)	Benefit-cost
Bolivia	3,318	715	-2,603
Colombia	18,122	1,097	-17,025
Ecuador	696	252	-445
Peru	1,901	53	-1,849

Fuente: Bonifaz (de próxima publicación).

In the second approximation, the exercise considered when non-irrigated lands begin to produce at the level of irrigated lands.[3] As can be seen in the following table, the benefit-cost analysis with this second approach is positive in all countries.

Table 2.7. General benefit-cost analysis. Irrigation (USD millions)

Country	Cost	Benefit (NPIV)	Benefit-cost
Bolivia	3,318	8,142	4,824
Colombia	18,122	40,777	22,655
Ecuador	696	1,397	701
Peru	1,901	2,885	984

Source: Bonifaz (to be published soon).

As can be observed, the costs of providing infrastructure in these sectors vary from country to country and with respect to the type of "solution" proposed. Overall, the benefits exceed the costs, so investing in this sector not only makes economic sense but also has social significance.

2.3 Recommendations

Investing in closing infrastructure gaps to support productivity growth in the agricultural sector is a winning strategy, not only from an economic but also from a social standpoint. As the previous sections show, the benefits of investing in infrastructure are greater than the costs in the Andean countries.

Farmers in Bolivia, Ecuador, Colombia and Peru are confronted with a poor and scarce road network, potentially restricting agricultural production. These countries have lower road density compared to developed countries. Consequently, investing in road network improvements (such as maintenance and construction of new roads) would reduce travel time and inefficiencies. In addition to the direct effect of the road network on agricultural income (profits), through the costs associated with production distribution and input demand, road networks directly affect the use of inputs in agricultural production. Agricultural inefficiency decreases with road density and increases with travel time for Peru, Bolivia and Ecuador. Technical inefficiency decreases, on average, by 0.9% for every 1% increase in road density. Results indicate that the largest marginal effect is found in Peru and Ecuador, with an average reduction of more than 3% in technical inefficiency for every 1% increase in road density.

Regarding road construction technology and materials, it is important to note that there is no information on the exact location of the farms, so investments could be overestimated. In such a case, proposing basic pavement solutions is profitable only in Colombia and Ecuador, although in Ecuador the suggested solution corresponds to a gravel road. In contrast, road investments in Peru exceed the net value of productivity, so it would not be profitable to invest in roads exclusively to improve agricultural productivity.

3 In this case, the NPIV corresponds to the new production of Irrigated land. A crop with an average yield of 15 MT/h and a domestic market price of USD 1.5 per kg has been considered. Also, a net cost income of 15% and a time frame of 15 years were considered (Bonifaz, to be published soon).

Investing in infrastructure to support the agricultural sector is a winning strategy. The benefits outweigh the costs.

On the other hand, investing in expanding access to energy can result in access to better information and inputs and thus increased agricultural production, thereby improving farmer income. In general, energy access is associated with higher agricultural production and is positively correlated with rural extension services and credit, but is negatively associated with proximity to cities of 50,000 inhabitants or more (or population densities of 1.5). Policies aimed at minimizing deficits in access to electricity in rural areas of Andean countries should consider scenarios of scarce public resources and economic and environmental sustainability. Projects involving off-grid initiatives and energy generation from renewable sources and waste are becoming increasingly common. These projects are often less costly than the construction of megaplants and grids that stretch across the country (Eras-Almeida and Egido-Aguilera, 2019). Initiatives such as Luz en Casa (Light at Home) and Microfranquicias para el Acceso a Energías Limpias (Microfranchises for Clean Energy Access), implemented in Peru and Bolivia, respectively, show that it is possible to scale up electricity distribution by taking into account local realities and non-traditional projects in the sector. Examples of these are wind and photovoltaic energies.

In all countries, access to energy increases the value of agricultural production. In Bolivia, access to energy in agriculture has the potential to increase the value of production by up to 29%. In Colombia, an impact of USD 520.58 on the value of production is identified in relation to energy use. Access to energy in Peru was associated with an average increase of USD 319.40 in the value of production.

Similarly, access to services such as rural extension and credit increases the likelihood of using electricity in agricultural activities. These results show that investments that expand the distribution of energy sources in rural areas have the potential to boost agricultural production. Access to modern energy services can improve working conditions on farms and facilitate access to better quality services, products, and technologies, resulting in higher productivity.

Adopting irrigation has the potential to double yields and, consequently, incomes. This technology has been widely discussed as a way to increase production to meet growing global demand; however, adoption by farms is costly. Several public policies have focused on irrigation, aiming to reduce direct farm costs through providing infrastructure (e.g., Programa Nacional de Riego con Enfoque en Cuenca, PRONAREC in Bolivia or National Irrigation Program with a Watershed Focus) and subsidies (e.g., Programa Subsectorial de Irrigaciones, PSI for drip irrigation in Peru or Subsectorial Irrigation Program). Only in the case of barren land development with a significant increase in productivity would it be beneficial to invest in irrigation.

A 10% increase in irrigated land in Colombia led to a 3.3% increase in production, all else equal. A 10% increase in irrigated land in Bolivia led to a 4.00% increase in production, all other factors being equal. In Ecuador, there was a 1% increase in agricultural production as a result of a 10% increase in irrigated land. Agricultural production in Peru resulted in a 7% increase as a result of a 10% growth of irrigated area.

2.4 Annex

A project can be evaluated from a private point of view and from a socioeconomic or social viewpoint. In the former case, a company is interested in knowing whether or not it is convenient for it to implement a given project. For this purpose, the evaluation will be made considering the benefits and costs involved in the project. In the latter case, a country or a region is interested in knowing whether or not it is in its interest to carry out a project as a whole. It is therefore necessary to take into account the benefits and costs perceived by all the inhabitants of the country or region.

The socioeconomic evaluation is concerned with whether the country is expected to achieve greater welfare in the scenario with the project than in the scenario without the project. Decision criteria for socioeconomic evaluations are the same as those used for private evaluations, i.e., net present value and internal rate of return. However, what differentiates the socioeconomic evaluation is: (i) the consideration of benefits and costs not taken into account in the private evaluation and (ii) the different valuation of benefits and costs, which are common to both. The following is an analysis of the theoretical framework related to project socioeconomic evaluation, but with an emphasis on benefits.

The benefits of a project for the country will be measured by the value of goods and services that will be additionally available to the country as a result of the project. The project produces goods and services, the value of which for the country depends on the use to which they are assigned. Obviously, if no one wants to use these goods and services, they will have no value and, as a result, there will be no benefits attributable to the project. Normally, when a new project produces a certain amount of a goods or services, the following is observed: (i) a greater use of them within the country, either because it increases their consumption (if they are a good for end consumption) or because they allow an increased production of other goods (if they are an input), and (ii) a decrease in the production by other producers of the same good.

The increased consumption of the good is undoubtedly a benefit for the country, since it provides direct satisfaction to the consumer (apart from the externalities that such consumption may generate). The increased production of other goods, which allows the increased availability of the good, will also be a benefit to the country, since the additional goods produced can, in turn, be consumed or used to produce more goods. On the other hand, the decrease in the production by other producers implies freeing up productive resources that can be used in the production of other goods, which can also be consumed or used in new productions. Consequently, they also constitute benefits of the project.

When conducting a socioeconomic evaluation, the effects that projects have on the markets for goods or services that would be directly produced or used by them are usually analyzed first. These are the so-called 'direct effects of projects'. Once the direct effects of the project have been estimated, those not taken into account in the private evaluation are added, i.e., the effects that the project will have on the availability of goods not considered when estimating the direct effects. These are the so- called 'indirect effects'.

To estimate direct benefits, the quantities of goods or services that the project would produce (per unit of time) are used as a starting point. In the economic evaluation, the quantities of goods or services that the project would produce in each future time unit are used as a starting point and compared to the scenario without the project. The benefit of a period Bt can be mathematically expressed:

$$B_t = \sum_i P_i X_i$$

where X_i is the quantity of goods or services i that would be produced by the project and P_i is the net price that the project owner would receive for each unit of those goods or services.

When the benefits corresponding to all the periods included in the project's analysis time frame have been established, the present value of the project's benefits is obtained, according to the following expression:

$$VA = \sum_t \frac{B_t}{(1+\delta)^1}$$

where δ is the discount rate that represents the opportunity cost of capital or the discount rate for the country or region that is attempting to decide whether or not to implement the project.

On the other hand, a project may also cause indirect effects (positive or negative), which should be included in the socioeconomic assessment. These are the effects that are observed due to the fact that, as a consequence of the project, other markets are affected. Thus, when a project is implemented and has a positive impact on the production of related goods, a quantifiable benefit is obtained. In other words, for indirect effects to exist, changes in the related activity are expected as a consequence of the project and that activity is altered by the absence of the project.

In order to estimate the indirect effects for a given period, it will be necessary to analyze the various markets for goods related to those that would be produced and used by the project. Total indirect effects for the period are obtained by aggregating the effects in each related market and are called indirect benefits.

Model assumptions and parameters

In order to conduct the evaluation of an investment in energy, roads or irrigation, it is necessary to have the following information:

a) The project's evaluation time frame.[4]
b) The opportunity cost established as a reference for the evaluation or the discount rate.
c) The benefits and costs of the project.

Discount rate[5]

The social discount rate (δ) measures the effective cost for the society of using capital in an investment and is used to discount the future benefits and costs of a government investment project and convert them into present values. Its use allows not only to determine the convenience of executing a given project,

4 In this exercise, a time frame of 15 years has been used.

5. Parameter that can be changed in the spreadsheet.

but also to compare it with other projects, whose flows have different time structures, and to establish a ranking of investment priorities, when available resources are scarce.

It is calculated as the weighted average of the rate of return on private investment (π) and the rate of chronological preference, considered as the average interest rate in the financial system (r).

$$\delta = \theta\pi + (1-\theta)r$$

The weights used, θ and (1 – θ), are obtained from the elasticities of investment and private savings with respect to the interest rate (η and ε, respectively), according to the following equations:

$$\theta = \frac{\eta}{\eta + \varepsilon} \quad \text{y} \quad 1 - \theta = \frac{\varepsilon}{\eta + \varepsilon}$$

where η is considered as the absolute value of the elasticity of investment, i.e., it is expressed as a positive value.

The social discount rate can therefore be expressed as follows:

$$\delta = \theta\pi + (1-\theta)r = \frac{\eta\pi + \varepsilon r}{\eta + \varepsilon}$$

Both elasticities are estimated using a multi-equation model, which depends on private investment, real savings, the real interest rate on domestic currency deposits, GDP, available income, public or government investment and the import-export ratio (this last variable represents the current account deficit).

It should be kept in mind that the resources obtained by the Government to finance a new public investment project originate, on the one hand, from the domestic financial market and, on the other, from the international financial market. The resources raised in the domestic market are extracted through an increase in the interest rate both from consumer savings and from loans that were intended for consumption.

In this respect, the discount rate to be used in the projects should be the one used in the Public Investment Systems of each country analyzed. For the purposes of this exercise, a discount rate of 11% will be used.[6]

6. This is the discount rate used in infrastructure projects in the public investment system of Peru. It is considered a reasonable value to carry out the exercise. In any case, this parameter can be modified for simulation purposes.

Net incremental value of production or project benefits

The Gross Value of Production (GVP) is the result of multiplying the total production of each of the crops in the Crop Schedule by their respective farm-gate purchase prices. The Net Production Value (NPV) is determined by subtracting the production costs of the Crop Schedule from the GVP. Like the GVP, the NPV must also be determined for the current situation as well as for the different alternative solutions (if any), in order to be able to subsequently perform the economic and social evaluation of the project. The Net Incremental Production Value (NIPV) is the additional income obtained by the direct beneficiaries from the implementation of the project.

In this exercise, the NIPV will be used as a measure of project benefits.

Economic evaluation of the project

The economic evaluation of the project is the main tool that a pre-investment study has to discard those alternatives that, from an economic standpoint, are not beneficial for the project. For an alternative to be considered as a project solution, its economic evaluation requires that it be shown to be profitable. Consequently, all those alternative solutions that have been shown to be cost-effective are suitable for selection as project solutions.

The most commonly used methodologies in economic evaluations of public investment projects are cost-benefit and cost-effectiveness. The cost-benefit methodology compares the benefits versus the costs of a project, where both benefits and costs are expressed in monetary terms (a single unit of comparison), and based on the construction of a cash flow, it allows the application of indicators such as the Net Present Value (NPV), the Internal Rate of Return (IRR) and the Benefit/Cost Ratio (B/C).

The cost-effectiveness methodology allows the cost of one, some or all of the project's determining variables to be established. This methodology is used when it is absolutely impossible to obtain the benefits in monetary terms. Thus, it enables the selection of the alternative that shows the lowest possible cost with respect to some of the project's determining variables.

3

Courtesy IDB / Valentina Porras.

INSTITUTIONALITY

3. THE ANDEAN INSTITUTIONAL FRAMEWORK OF THE AGRICULTURAL SECTOR: OPPORTUNITIES FOR STRENGTHENING

3.1 Introduction

This chapter highlights the importance of the institutional framework and its political and technical mechanisms as determining factors for the development of the agricultural sector in the Andean countries. Its approach is decisive, basically because it defines the rules of the game, incentives and the supply of public goods that contribute to the productive and inclusive development of this sector. There are also several aspects that have been decisive in documented success stories in Latin America, including cases in the Andean countries, for the successful inclusion of agro-industrial chains in international markets (Ghezzi *et al.*, 2022). Among these aspects, this chapter highlights the provision of public goods, an intentional and well-targeted inclusive approach towards small farmers, effective coordination between the public and private sectors to identify, prioritize, and address sector bottlenecks, and the prevailing vertical structure and siloed operation of the institutional framework in our region.

Similarly, this chapter refers to the institutional peculiarities of each Andean country, with the exception of Venezuela, including their opportunities to strengthen and even transform their sectorial institutional framework in order to boost agriculture as a driver of economic growth, well-being, and social inclusion, and to catapult their successful integration into food export markets to achieve food security in the Andean region. For example, in the case of Bolivia, the institutional particularities include the wide range of public services, programs and projects that operate in the sector, the main advantage of which is greater operational agility and flexibility, while the disadvantage is the dispersion of resources, which limits the impact and coherence of support actions. An important institutional characteristic of the agricultural and livestock sector in Colombia is the collaboration between public and private institutions, mixed participation corporations, and private entities with decentralized organizations. Together, they enhance the effectiveness of sector support policies designed at the central level. One of Ecuador's institutional characteristics is that it has developed, through the Ministry of Agriculture and Livestock (MAG), a state policy for the agricultural sector with strategic objectives for the period 2020-2030, defined on the basis of production challenges and the needs of workers and the rural population. In Peru, the policy priorities implemented in recent years have focused mainly on the modernization of family agriculture, adaptation to climate change, technological innovation, financing, market development, irrigation and water resource management, animal and plant health and food safety.

The main shared challenges in terms of institutional strengthening include animal and plant health and food safety, research, innovation and technology transfer, better policy planning, and efficient

coordination among the various institutions, programs and projects. It should also be noted that there is a window of opportunity for strengthening holistic-oriented support for small-scale family farming, covering aspects ranging from financing to associativity. The common recommendations for the Andean countries include improving coordination among ministries in order to take better advantage of economies of scale, avoid duplication and increase focalization. It is also suggested that priority be given to health and food safety services affecting the most important crops, that efforts be focused on innovation and technology transfer to increase productivity and competitiveness and resilience to climate change, and that policy formulation be strengthened through its evaluation.

3.2 Importance of institutional frameworks for the sustainable and inclusive development of Andean agriculture

Being a transversal component, the institutional and public policy approach is a determining factor that sets the standard for the type of environment, incentives, bottlenecks and the way to solve them in terms of productive development. This is no exception when it comes to the processes of articulating agro-industrial value chains and their successful insertion into international markets. In this regard, a recent study led by the IDB and edited by Ghezzi *et al.* (2022) highlights several aspects related to the institutional framework that play a crucial role in the development of agro-industrial value chains. This section mentions only some of the most relevant in the context of the Andean countries.

A first aspect has to do with the provision of public goods by the State[1], which is necessary to ensure that growers comply with the multiple requirements for exporting. This involves a diverse array of areas ranging from animal and plant health, food safety, certification, scientific research and technological development to social and environmental impact matters.

A second important aspect is the intentional, well-focused and necessary inclusive approach that public policies must adopt in order to successfully integrate small-scale growers into value chains. Because the needs and shortcomings of small farmers are very different from those of large farmers, an institutional framework is needed that offers a holistic range of support and mechanisms in terms of infrastructure, technical assistance and access to financing, just to mention the most important ones.

A third key aspect is effective coordination between the public and private sectors to identify the main bottlenecks and the public goods required to overcome them. An equally necessary and often overlooked strategic approach is required to establish priorities and the sequence in which they will be addressed. For example, if the most pressing obstacle is a lack of connectivity infrastructure or if it's an issue related to the absence of a traceability system, to mention one case among many possibilities.

Regarding this matter, a reference highlighted in this study is that of the executive roundtables (ER) in **Peru**, designed by the Ministry of Production to implement effective productive development policies through public-private working groups. Their main objective is to identify bottlenecks in specific sectors and implement solutions for them. One of the positive impacts of these ERs has undoubtedly been that through this joint public- private collaboration, reforms have been made in public entities to strengthen institutional frameworks.

1. Public goods are understood as a series of goods and services that provide massive benefits to companies and individuals, where the benefit of one does not affect the benefit of the other. For theoretical details of public goods, see Oakland (1987).

The final aspect to be highlighted in this section regarding the study by Ghezzi *et al.* (2022) is the predominant vertical structure of public institutions in Latin America, comprising ministries and agencies that tend to operate in silos, with little or no articulation or coordination. As a result, the solutions to the problems or needs identified in the agricultural sector are quite often distributed among agencies other than the Ministry of Agriculture and its vice-ministries. As will be discussed in the next section, the institutional structure of the agricultural sector in the four Andean countries analyzed is vertical and each has its own distinctive characteristics. The fourth section also mentions several institutional challenges related to low coordination, siloed work and lack of information sharing. Based on the study, in view of the emergence of increasingly demanding and rigorous international standards and the need for agrifood systems that are agile, modern and reliable, the current vertical structures that operate in silos should not ignore this call if they are to successfully insert agroindustrial chains into export markets.

Institutionality plays a crucial role in the development of agroindustrial value chains, including the provision of public goods, an inclusive approach and effective coordination between the public and private sectors.

3.3 Current institutional framework of the Andean countries

This section focuses on describing the agricultural institutional framework in each of the Andean countries. The information contained here for each country is based on the work of Carlos Furche on the institutional framework and agricultural development in Bolivia, Colombia, Ecuador and Peru (Furche, to be published soon). It should be noted that Venezuela is not included.

The institutional framework for agriculture in **Bolivia** is characterized by a strong State presence through its ministry responsible for the sector, a variety of programs and projects promoted by the State and even direct participation through public enterprises in specific sectors. A particular institutional feature of the country's agricultural sector is the number of programs and projects to support its small and medium-sized growers, which have great operational agility, compared to the less specific support from the central administration. In contrast, the institutional challenges facing the country are related to efficiency, coordination and articulation of this state support, and the lack of private support to improve the production process with increased technology adoption and productivity of the sector.

Leading the institutional structure of Bolivia's agricultural sector is the Ministry of Rural Development and Lands (MDRyT) as the State entity responsible for defining and executing public policies oriented towards this sector. Its organization is consistent with the importance of the sector in the Bolivian economy, since it allows it to maintain a variety of functions in the areas of supporting food production, generating foreign exchange through exports or import substitution, improving the living standards of the rural population, and caring for the environment, among others. In turn, the organizational structure of the MDRyT is composed of three vice ministries, a General Directorate of Planning, which maintains the same hierarchical level as the previous ones, and complementarily, decentralized entities under the MDRyT that address various aspects of sectorial management in a more operational fashion.

The Vice-Ministry of Rural and Agricultural Development is the largest of the three and is in charge of the General Directorate of Rural Development, which has technical units specialized in information, policies and studies and program coordination. Within this Vice-Ministry is also the General Directorate

of Agricultural Production and Food Sovereignty, which includes units specialized in agricultural production, agroforestry and fisheries, agricultural health and food safety policies, and a rural contingency unit. The Vice-Ministry of Lands is in charge of specialized technical units for land regulation and titling, and land information. Finally, within the central structure of the MDRyT, the Vice-Ministry of Coca and Integral Development was incorporated in 2009, reflecting the importance of this crop in the country and the state's interest in promoting it. It is composed of units specialized in industrialization and integral development of the two coca leaf producing areas of the country, namely the Yungas and the Cochabamba tropics.

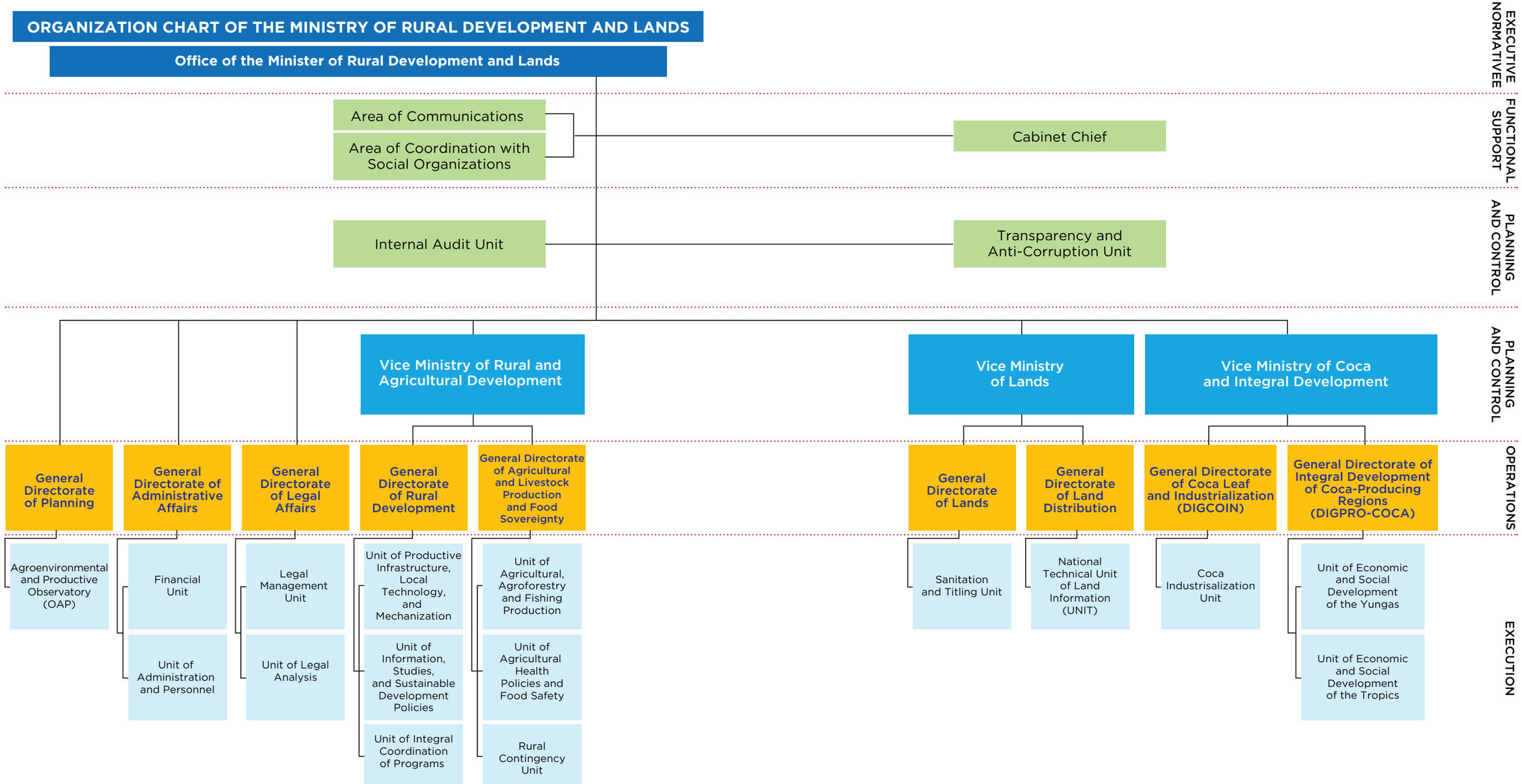
As in other countries in the region, the institutional framework of the MDRyT described above is complemented by a set of dependent decentralized entities. These entities maintain various specific functions, including support to production through research, technical assistance, technology transfer, and management of sanitary aspects, genetic resources and diversity. Among the support services provided by these entities are the certification of products and seeds, and border control to prevent the proliferation of diseases and pests.[2].

The agricultural institutional framework of Bolivia is characterized by a strong state presence, a variety of state-driven programs and projects, and direct participation through public enterprises in especific sectors.

A most important entity is the National Agricultural Reform Institute (INRA), whose strategic objectives are to achieve the titling of agricultural property through a transparent process and to provide public cadastral information. Its most complicated task is to regulate land titling, which only reaches 13% of the country's agricultural area to date, according to its data.

2. The two key entities in these efforts are INIAF and SENASAG. Others that are important in supporting the sector are IPDSA and FONADIN, in charge of promoting food security and sustainable development in specific coca production areas.

Figure 3.1. MDRyT organization chart



Fuente: Ministerio de Desarrollo Rural y Tierras.

Functions and services offered by the MDRyT in Bolivia are complemented by the actions of other ministries and public agencies that work in rural areas and operate with support instruments, especially some aimed at small farmers. Among these institutions is the Ministry of Productive Development and Plural Economy, created in 2009 to transform and add value to natural resources within a framework of environmental sustainability. Under its administration is the management of various public companies, several of which operate directly in the agricultural sector, such as Empresa Azucarera San Buena Aventura (EASBA), Empresa Boliviana de Alimentos (EBA), Empresa de Apoyo a la Producción de Alimentos (EMAPA), among others. The Ministry of Environment and Water is also focused on the regulation and management of water resources. Its main challenge is to provide adequate policies and management instruments to increase the area under irrigation and improve efficiency in the use of available resources, responding to and coordinating with the promotion of productive diversification programs in the sector and the incorporation of small and medium-sized producers into more profitable activities.

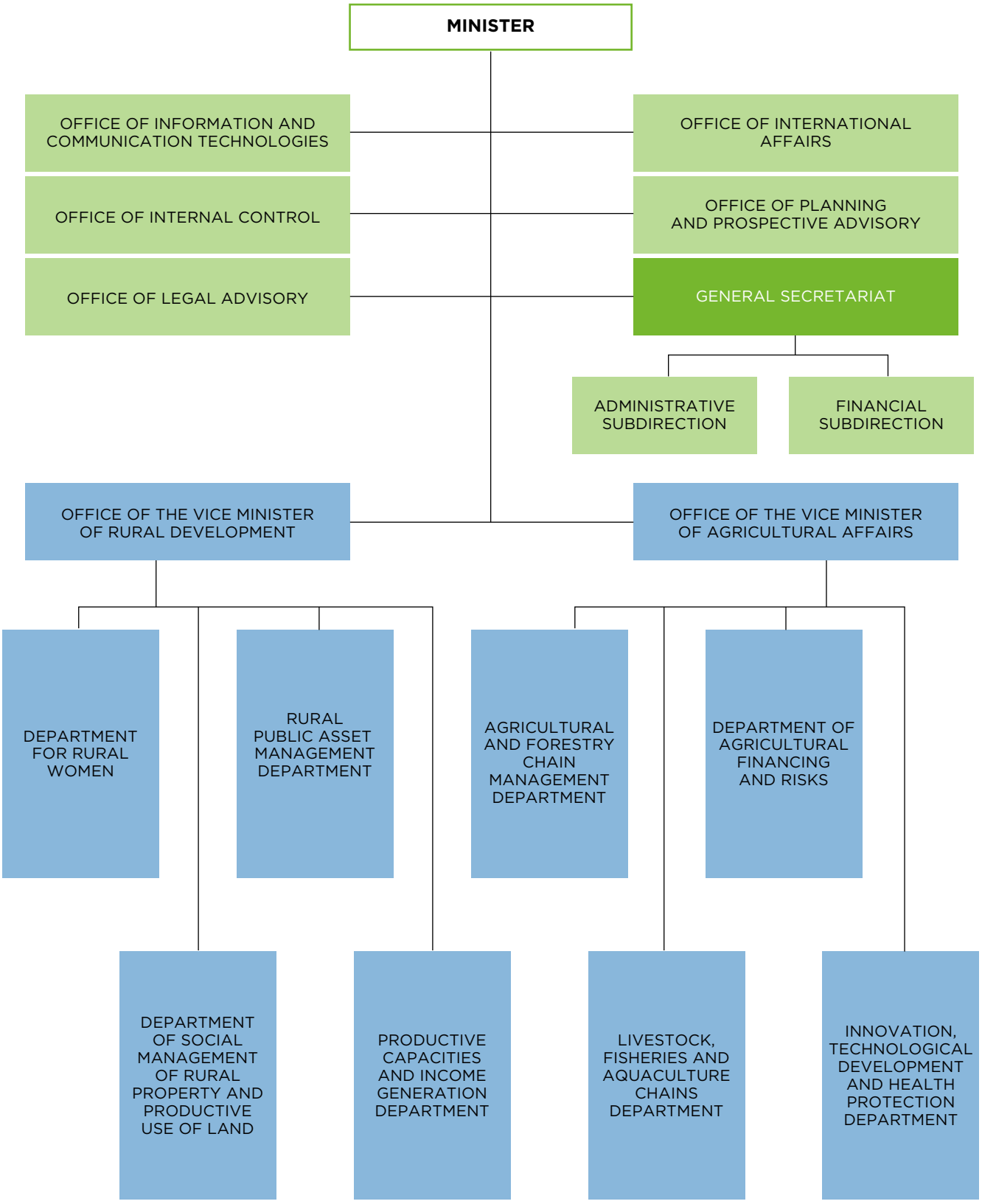
Finally, it is important to mention private institutions. The regional and productive heterogeneity of Bolivian agriculture is also reflected in the organizations of its producers and the type of support they offer to their associates. Two of the most important are Fegazacruz in the meat production chain and ANAPO in the oilseed producers' sector. Both of them represent their associations and provide services to their members in areas such as technical assistance, marketing support and certification for the movement of animals and insertion into export channels (in the case of Fegazacruz) and technology transfer, training and marketing support to their members (in the case of ANAPO).

Colombia, on the other hand, has a solid institutional framework that allows it to enhance the agricultural and livestock sector through public policies. A notable characteristic of the Colombian institutional framework in the sector is the complementarity between the support from the public sector and private expertise. The priority areas for institutional strengthening are closely related to the challenges the country faces regarding population flows across its borders and climate change, as well as ensuring resilience in supporting increased sector productivity, especially through irrigation infrastructure.

As for its institutional structure, the Ministry of Agriculture and Rural Development (MADR) is the government department responsible for formulating and implementing public policies in the agricultural sector. It consists of two deputy ministries: The Deputy Ministry of Rural Development and the Deputy Ministry of Agricultural Affairs. This organization corresponds to the two main areas of responsibility within the ministry: on the one hand, managing issues related to the quality of life of rural inhabitants and rural space organization, and on the other hand, overseeing policies and support mechanisms for agricultural and livestock production.

A noticeable feature of the Colombian institutional framework in the sector is the complementarity between public sector support and private sector.

Figure 3.2. Organization chart MADR



Source: Ministerio de Agricultura y Desarrollo Rural.

Specialized technical units comprise each vice-ministry in order to carry out its functions. Noteworthy among these are the units within the Vice-Ministry of Rural Development that are responsible for gender promotion aimed at rural women, rural property and land use, as well as productive capacities and income generation. Another fundamental task of this Vice-Ministry is the regularization of land allocation, including those lands that were directly affected by the armed conflict suffered by the country during the last decades.

The Vice-Ministry of Agricultural Affairs is focused on supporting agricultural and livestock production processes and is responsible for formulating policies and coordinating efforts to support the productive development of the agricultural sector, both in terms of its regulatory framework and the instruments and services to support production. Among its most important specific functions are the coordination of productive rural development programs, financing, technical assistance and training, and the provision of technology and infrastructure support for the sector.

Colombia's territorial extension and geographic diversity make decentralized management of the public system very important. Consequently, in addition to the central structure of the Ministry, it is essential to take into account in the sectoral public institutional framework a set of affiliated entities that are mainly responsible for the operational management of the Ministry, as well as related entities that, although they do not depend on the MADR, are closely related to it. Likewise, corporations with mixed public-private participation must also be taken into account.

Among these affiliated entities, the work of ICA (the Colombian Agricultural Institute), which has a long history of support for the country's agricultural sector, is worth mentioning. Among its main functions are the prevention, surveillance and control of sanitary, biological and chemical threats and risks in the sector. Other entities are the Rural Development Agency and the Territorial Renewal Agency, whose respective functions are to strengthen the associativity of producers and rural populations, and to coordinate the intervention of national and territorial entities in rural areas affected by the armed conflict with the FARC guerrillas.[3]

On the other hand, the related entities do not depend directly on the MADR; however, due to the definition of their attributions and functions, they are closely linked to the MADR and have a major impact on the country's agricultural development. Among the most important are those entities dedicated to strengthening the financing of the agricultural sector, such as the Agrarian Bank, FINAGRO, COMCAJA, FIDUAGRARIA, the Mercantile Exchange, and others.

Finally, corporations with mixed participation, including the Corporación Colombiana de Investigación Agropecuaria (AGROSAVIA) and the Corporación Colombiana Internacional (CCI), have the purpose of undertaking research to generate adaptation and technology transfer in the sector, as well as providing specialized education in production quality and the development of competitive and sustainable agroindustry models.

There are also other institutions that support the agricultural sector in Colombia. Among the public agencies that complement the work of the MADR in the area of production and rural development are the National Planning Department (DNP) and the Ministry of the Environment and Sustainable Development (MMADS). The DNP works closely with the MADR as a priority element, since it is responsible for coordinating the design of plans, policies and programs that address sectoral and territorial needs, and for strengthening technical capacities in the sector to promote productivity, competitiveness, sustainability and equity. On the other hand, the MMADS is mainly responsible for agricultural productive activity within environmental regulation, as well as the development of strategic plans to ensure the availability of water resources for the sector.

3. The conflict with the Revolutionary Armed Forces of Colombia (FARC) lasted approximately six decades; one of its main factors of prevalence was the ownership and use of agricultural land, which was precisely the first point of the Peace Treaty signed in 2016.

The private institutional framework in the sector is also worth mentioning. The National Federation of Coffee Growers of Colombia, whose existence dates back to 1927, and brings together more than 340,000 growers, should be highlighted. Its organization finances scientific research activities and purchase insurance services, as well as promotions and publicity for its associates. The Colombian Federation of Cattle Raisers (FEDEGAN), created in 1963, supports producers in taking advantage of the country's great cattle- raising potential, which is relevant for competitive integration into international markets, through support for animal health and technological innovation in the sector.

Ecuador adopted a state policy for the agricultural sector focused on reducing poverty and generating employment in rural areas, prioritizing food safety and strengthening productive resilience to climate change.

In the case of Ecuador, the Ministry of Agriculture and Livestock is the main entity within the institutional framework of the agricultural sector. Its tasks are distributed in its two main components: productive development and rural development. It should be mentioned that between 2019 and 2020 the country adopted a state policy for this sector, with

strategic objectives set for the period 2020-2030, focused on reducing poverty and generating jobs in the rural area, prioritizing food security and strengthening productive resilience to climate change. There is much room for opportunity in terms of institutional strengthening, especially to take advantage of the natural advantages offered by its geography. In particular, the low level of productivity requires greater support in health and safety, as well as more research, innovation and technology transfer in the sector. Similarly, among its critical points, the country requires investment in road and irrigation infrastructure to strengthen the agricultural and livestock sector.

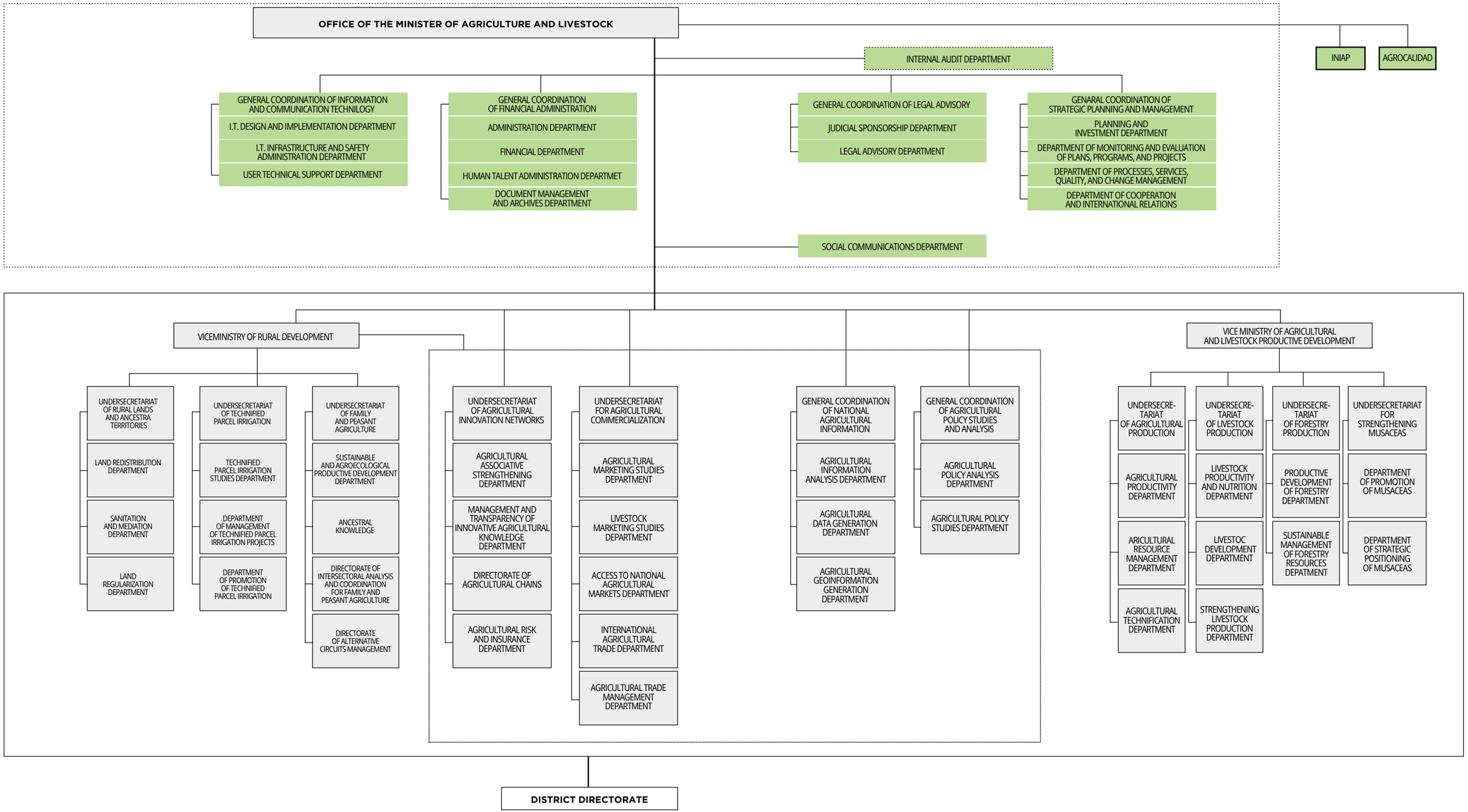
Regarding the institutional structure, the Ministry of Agriculture and Livestock (MAG) has two major divisions under which it carries out its functions according to its organic management statute.[4]On the one hand, the Vice-Ministry of Productive Development has technical units specialized in agricultural, livestock and forestry production, productive development and regulatory activities. Among its main tasks are research, technology transfer and management support with a view to improving the productivity of each subsector. In addition to productive development, it also seeks to ensure the sustainability of the country's forests. The Vice-Ministry of Rural Development has specialized technical units responsible for land regularization and delivery, irrigation at the production unit level and technical support for family agriculture.

The work of these two vice-ministries is supported by four undersecretariats. The Undersecretariat for Agricultural Innovation Networks covers a wide range of issues, from agricultural insurance to support for associativity and the management and transfer of innovations. The Undersecretariat for Agricultural Marketing manages marketing support and international trade. The Undersecretariat for National Agricultural Information is responsible for generating and analyzing sectoral information. Finally, the General Coordination of Agricultural Policy Studies and Analysis is responsible for policy studies and analysis.

Finally, under the hierarchical dependence of the Minister of Agriculture, there are also its two main specialized services: The National Agricultural Research Institute (INIAP) and the Agency for Phytosanitary and Animal Health Regulation and Control (AGROCALIDAD). Both institutions play a fundamental role in the organization of the Ministry and its legal and administrative framework, with significant management autonomy.

4. Corresponds to the complete and detailed version of the organizational management statute published in Official Registry No. 572 of October 4, 2018.

Figure 3.3. Organization Chart MAG



Source: Ministerio de Agricultura y Ganadería.

As part of other institutions that support the agricultural sector, the scope of regulations, programs and public actions focused on direct or indirect action in Ecuador's agricultural sector are part of what is defined in the country as "Expanded Institutionalism", which includes other ministries and public agencies and even, in some cases, private entities.

Among them, whose relationship with the MAG is considered a priority for coordination, is the Ministry of Environment, due to its growing importance in meeting strategic objectives of sustainable production and resilience to climate change. Similarly, the Ministry of Production, Foreign Trade, Investment and Fisheries maintains efforts to coordinate the setting of priorities and development instruments focused on agricultural exports. The planning and provision of infrastructure by the Ministries of Water and Transportation are closely linked to the above. In parallel, the Ministry of Economic and Social Inclusion and the Ministry of Health must coordinate with the MAG to fulfill their strategic objectives and, in particular, to execute their functions focused on rural development.

The implementation of sector policies in Peru has been a determining factor for the development of the agricultural sector.

It is important to highlight that a District Directorate with rural and productive development units is part of the MAG structure, both with the purpose of articulating the policies and actions of the respective vice-ministries with their operation at the provincial and cantonal (municipal) government level. This greatly benefits the efficient execution of their functions by allowing for decentralized action that is well adapted to regional realities and needs.

Peru's agricultural sector development is characterized by its dynamism and its role as one of the pillars of the country's economic development. The institutional foundations laid for this dynamic development have been decisive, particularly due to the sustained implementation of sector policies. Among the most relevant are the promotion of irrigation, the development of the phytosanitary and animal health heritage, and the effective use of trade opening. The latter has enabled the country to become competitive in international markets, making agricultural exports one of the main drivers of the sector's recent development. Several studies illustrate the positive impact of trade agreements with Peru on agri-food exports, such as blueberries, avocados, grapes and chestnuts.[5] On the other hand, given Peru's institutional organization and the challenges facing the agricultural sector, it is a priority to focus efforts on increasing productivity through the adoption and transfer of technology, adaptation to climate change, as well as the promotion of sustainable agriculture and greater support for small and medium-sized producers, who are highly dynamic agents in the sector.

In terms of institutional structure, the Ministry of Agrarian Development and Irrigation (MIDAGRI) is the State body in charge of public policies aimed at the agricultural sector. Its organizational structure has been subject to various adjustment attempts in response to production challenges and the needs of the rural populations linked to its production. Within this framework, the current organization of MIDAGRI is divided into two vice-ministries: the Vice-Ministry of Agrarian Development Policies and Supervision and the Vice-Ministry of Family Agriculture Development and Agricultural Infrastructure and Irrigation.

The Vice-Ministry of Agricultural Development Policies and Supervision is in charge of agricultural policies, their monitoring and evaluation, land management and sanitation, and the cadaster of agricultural property focused on rural areas. Its tasks are mainly focused on formulating sectoral policies, conducting

5. Ghezzi and Stein (2021); Pérez and Gómez (2022) and Hidalgo (2021b).

economic studies and analyses, monitoring and evaluating policies in operation and generating useful sectoral information for public and private decision-makers. It concentrates main technical support tasks for managing the ministerial authorities.

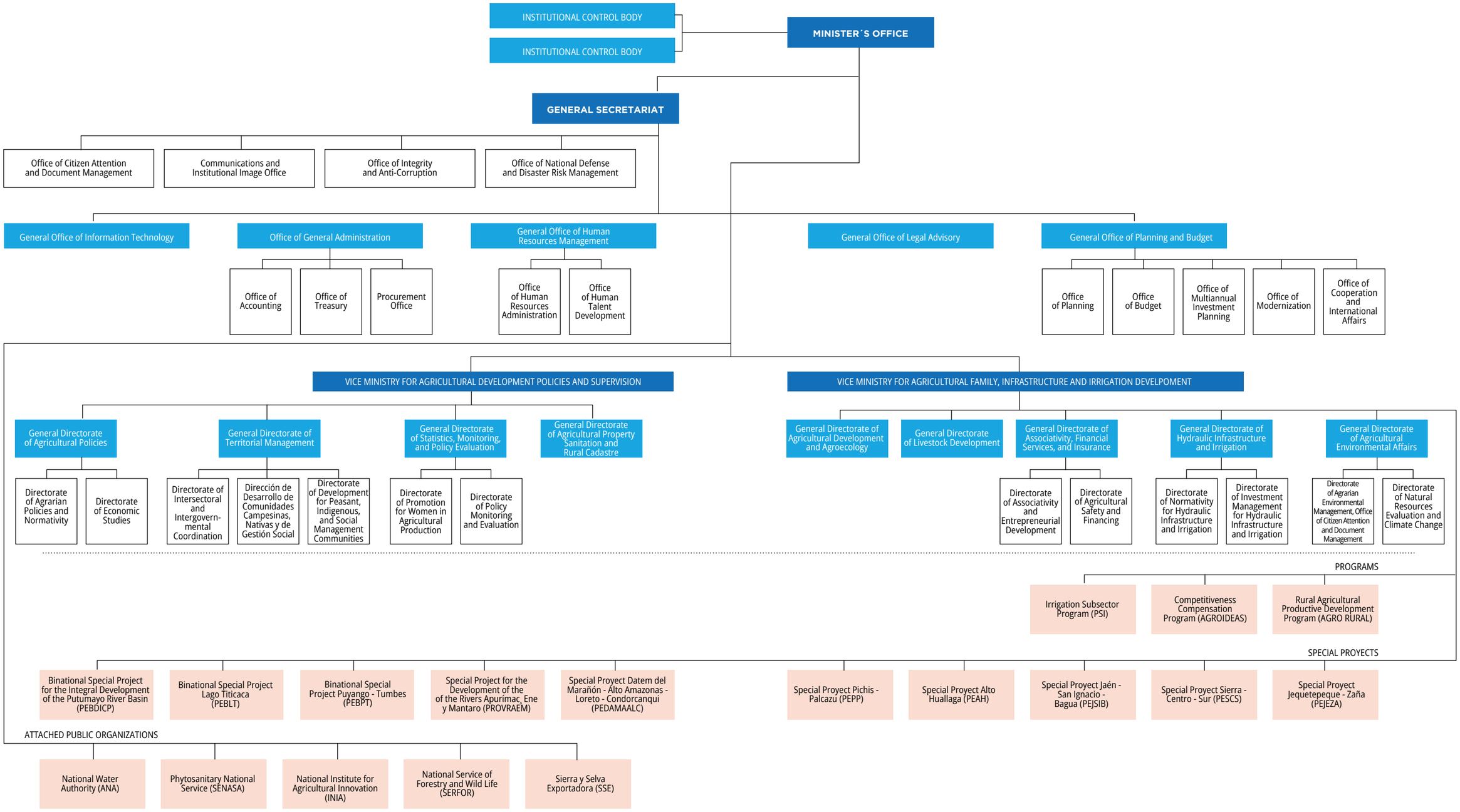
Courtesy of IDB.

The Vice-Ministry of Family Agriculture Development, Infrastructure and Irrigation focuses on agricultural development and agroecology; livestock development; associative financial services and insurance; water and irrigation infrastructure; and agricultural environment issues. The action of this Vice-Ministry prioritizes support for family agriculture, both in its regulatory dimensions and in its financial support and promotion of irrigation, technical assistance and, in general, the operation of policies to support productive development.

In addition to the central organization, there are entities attached to MIDAGRI that have a greater degree of autonomy in performing their tasks since they are governed by a specific set of regulations and have professional staff and budgets assigned to them by law. These entities take advantage of their autonomous flexibility to develop specific tasks and adapt to the needs of the sector in the fields in which they work. The main entities are in charge of providing agricultural health services (SENASA), which is very important to ensure the quality of products for export; innovation (INIA), with support for research and technology transfer in the sector as well as its respective regulation; the promotion of access to international markets, as in the case of Sierra y Selva Exportadora, which promotes training programs and facilitates the access of producers to international fairs; the general administration of the country's water resources (ANA); and forestry management (SERFOR).[6]

6. In order, SENASA (Servicio Nacional de Sanidad Agraria), INIA (Instituto Nacional de Innovación Agraria), ANA (Autoridad Nacional del Agua), SERFOR (Servicio Nacional Forestal y de Fauna Silvestre).

Figure 3.4. MIDAGRI organization chart



Source: Ministerio de Desarrollo Agrario y Riego.

The ministerial structure also includes various programs under MIDAGRI (Ministry of Agriculture and Irrigation) designed to promote policies and instruments aimed at achieving specific objectives. Among these, Agrorural stands out, focused on financing public investment projects and other interventions in economically underdeveloped rural areas, in the context of the Law for the Promotion and Development of Family Agriculture. Agroideas is oriented towards promoting the competitiveness of small and medium-sized producers through cooperation and the adoption of agricultural technologies. It is also responsible for formulating, directing, and supervising projects for agricultural reconversion, prioritizing certain crops considered sensitive. Procompite's purpose is to enhance the competitiveness of productive chains through the development, adaptation, improvement, or transfer of technology in areas where private investment is insufficient to achieve competitive development and sustainability of the productive chain. Finally, the Subsectoral Irrigations Program (PSI) aims to improve productivity and ensure more efficient use of water resources, with considerable state support directed to subsidizing production in organized sectors in disadvantaged areas of the country.

Regarding other institutions that support the agricultural sector, it is evident that the development of complex production processes, such as those that have consolidated their position in international markets and those with value chains, requires the intervention of numerous private and public actors. In the case of Peru, the existence of various laws and regulations, as well as policies to promote and stimulate the development of different actors in the agricultural chains, determines the need to coordinate the actions of MIDAGRI with other ministries and public agencies.

Among the main entities that influence the development of the agricultural sector are the Ministry of the Environment, which regulates production processes and focuses on environmental sustainability; the Ministry of Health, which is linked to food safety and sanitary conditions and has special regulations, including the most important one concerning food labeling, which has compelled the agro-industry to adapt to new regulatory requirements; and the Ministry of Transport and Communications, which is essential for sectoral competitiveness as it determines the availability of suitable physical connectivity routes and the infrastructure of ports and airports for the provision and commercialization of sector products.

3.4 Challenges in Institutional Strength

Health and food safety is one of the main areas to be prioritized for institutional strengthening in **Bolivia's** agricultural sector. Bolivia has a specialized service through SENASAG (Servicio Nacional de Seguridad Agropecuria e Inocuidad Alimentaria), which is present throughout the country and has experience in sanitary control and disease eradication. The constant expansion of trade flows and movement of people and cargo transportation, in addition to extensive borders that are difficult to control, require a systematic effort to strengthen this ministerial function in its technological infrastructure and specialized technical teams.

A second challenge is in research, innovation and technology transfer. Although these tasks are usually considered part of a single system and, in this case, are institutionally assigned to INIAF (National Institute for Agricultural and Forestry Innovation), it is necessary to understand that they are, in fact, subsystems that require differentiated institutional mechanisms and incentives, especially given the heterogeneity and rich diversity of the country's agriculture.

Planning policies and information are also a priority institutional challenge. Although the structure of the MDRyT includes a General Directorate of Planning at a high hierarchical level, it would be advisable to strengthen this structure in order to have technical teams specialized in policy formulation for the sector as a whole.

Finally, the diversity of institutions, programs and projects, and the wide variety of tasks assigned to them, pose the challenge of coordinating efforts efficiently to achieve effective public policies and instruments to support the sector, without forgetting the issues of institutional coordination and articulation. The agricultural sector has a wide-ranging institutional framework, which, although centered on the MDRyT, must consider coordinating with other ministries that define regulations and develop plans, programs and projects that have an impact on the sector.

Regarding institutional strengthening in **Colombia**, one of the priority challenges is the issue of animal and plant health and food safety. While there are institutions in charge of these areas, the challenges facing the country, such as the increase in human circulation and climate change, require greater efforts. Another challenge is innovation and technology transfer, with special emphasis on supporting small and medium-sized entrepreneurs. While research needs in traditional products are well covered even with private participation, as in the case of the Federation of Coffee Growers, there is still a considerable deficit in agricultural innovation. Another challenge lies in productive development, which requires greater support in terms of increasing productivity.

Ecuador's institutional challenges can be summarized in three groups. The first refers to reinforcing sectoral policies with the primary goal of increasing the sector's productivity and consolidating the comparative advantages it enjoys, given its geography and climatic characteristics. Second, institutional development focuses on the formulation and evaluation of policies in order to monitor and enhance their effectiveness, especially to improve the generation and circulation of information necessary for decision-making by public and private sector agents, expanding and managing the current Agricultural Public Information System (SIPA). Regarding rural development, it is essential to support small-scale family agriculture by strengthening the MAG to reinforce efforts in key factors that limit the development of small-scale agriculture, such as financing, technical assistance, marketing support and associativity.

Given the new competitiveness factors needed to maintain and enhance **Peru's** comparative advantages derived from its natural conditions and geographical position, there are important sectoral challenges that require priority attention, such as resilience to technological change, efficient water resource management and the implementation of soil drainage technologies. On the other hand, it is necessary to enhance public policies aimed at regulating and promoting sustainability, productivity and marketing. Another characteristic is the heterogeneity of producers in rural areas, so the challenge lies in uniting efforts with the less privileged, such as small and medium-sized farmers.

3.5 Recommendations for strengthening the institutional framework for the agricultural sector in the Andean countries

The most renowned experiences among Latin American and Caribbean countries, such as Uruguay and Chile, are noteworthy because they developed a set of relevant functions for sectoral management. These include the formulation of medium- and long-term policies with definitions and strategic guidelines for sectoral development, and the preparation and dissemination of specialized economic information, made available to public and private agents for better decision making. For this reason, it is necessary to strengthen institutional mechanisms and entities that allow for a more effective ministerial coordination with other public agencies operating in the sector.

Among the main recommendations, in the case of Bolivia, emphasis is placed on the need for specific policies and instruments to support productive development, productive diversification, increased productivity and better adaptation to the effects of climate change. Special priority should be given to expanding the area under irrigation and increasing efficiency in the use of water resources through technified irrigation techniques. Additionally, it is important to develop mechanisms to encourage investment within productive units in order to increase technified irrigation. As for the challenges posed by this expanded institutional framework in the country, although the MDRyT is at the center, it is recommended to consider articulating with other ministries that define regulations and develop plans, programs and projects that impact the sector as a way to take advantage of economies of scale, avoid duplication and achieve better targeting and impact of support programs and instruments.

Regarding animal and plant health and food safety, the recommendations for **Colombia** include focusing support policies and instruments on mitigating the impact of diseases and pests that affect the country's major crops, such as coffee production and various fruits. In the area of innovation and technology transfer, it is suggested that efforts be focused on generating adequate support and incentives, while in the case of productive development and productivity, it is urgently proposed that policies be focused on irrigation infrastructure. Lastly, policy formulation and institutional coordination require that those planning and policy formulation functions previously performed by the Colombian Agricultural Institute (ICA), which are now institutionally dispersed, be placed in a unit specializing in studies and policies consolidating the coordination of the National Planning Department and other government entities to coordinate, above all, their financing. It is also recommended to strengthen capacities at the central level and in decentralized entities in order to enhance the effectiveness with which public policies have an impact on the sector.

The main recommendations for **Ecuador** include prioritizing health and safety services, strengthening research, innovation and its essential technology transfer to keep the sector competitive, as well as strengthening the resilience of production to climate change and the strategic approach to the growing environmental challenges. It is also suggested that efforts be focused on providing the necessary infrastructure to boost production and marketing, through strategic plans coordinated with the equitable supply of water resources with irrigation infrastructure and greater road and port connectivity. Finally, it is necessary to strengthen associativity and private participation to take more and better advantage of sectoral information and solve problems that affect groups of growers with greater public-private coordination, as well as to increase their efficiency.

Taking into account the current institutional framework of **Peru's** agricultural sector and the main sectoral challenges, efforts should focus on strengthening the existing institutional framework through the formulation of monitoring and evaluation policies by empowering its technical teams, especially in terms

of evaluating the impact of the policies and instruments used by MIDAGRI. Accordingly, it is suggested that regional and local coordination be strengthened, given that the agricultural sector is characterized by wide geographic spread, making it necessary to have mechanisms to ensure the presence of the Ministry and its institutions at the local level and, at the same time, to guarantee coordination with institutional entities at the regional and local levels.

On the other hand, boosting the sector's productivity through institutional support for family farming, financing for small and medium-sized producers, considering their important contribution to the dynamics of the sector, and the promotion of and greater support for innovation and technology transfer are essential in order to continue promoting their competitiveness in international markets. Strengthening irrigation and drainage infrastructure for the production phase, as well as road, port and air transport infrastructure for marketing, is also necessary. Finally, it is crucial to maintain and strengthen support for food health and safety, as well as the resilience of production to climate change, and to focus on maintaining production with the mitigation of harmful effects on the environment.

4

CLIMATE CHANGE

4. THE AGRICULTURAL SECTOR FACING CLIMATE CHANGE: A CALL TO ADJUST PRIORITIES AND GET TO WORK

4.1 Introduction

This chapter addresses the issue of climate change as a crucial factor for developing the agricultural sector and its impact on the growth and welfare of the Andean countries. On the one hand, it is identified as one of the greatest challenges currently facing the agricultural sector, in a context where it is also one of the most important and urgent challenges that mankind is confronting today.

On the other hand, the aim of this chapter is to convey a sense of urgency that will motivate a significant change in priorities and deadlines for action.

A series of available data confirms that the Andean countries are threatened by global climate change through their high or medium vulnerability to adverse climatological effects, largely due to their lack of preparation, as well as the high direct impacts they are subject to in socioeconomic terms. Some available figures give an account of the gravity of the situation; for example, floods and droughts in Bolivia in 2007 and 2016 have had the highest economic and human impact on record, with losses of 4.5% and 1.3% of GDP, respectively, affecting 8.6% and 6.1% of the population (World Bank, 2009a).[1] In Colombia, floods in 2011 had the greatest impact on record, with a cost of 0.7% of GDP, affecting 3.3% of the population. In the case of Ecuador, floods generated the maximum loss in 2008 amounting to 1.6% of GDP and affected 2.0% of the population. The greatest impact of these events in Peru was recorded in 2017, resulting in losses of 1.5% of GDP and affecting 6.8% of the population.[2]

Regarding the impact of climate change on the agricultural sector in the Andean countries, Prager *et al.* (2020) study shows that this productive sector is very sensitive to changes in temperature and rainfall, which generate impacts on productivity, trade and food security. Based on their general circulation models, forecasts obtained from this study suggest that temperatures will increase between 1°C and 4°C by 2050, with the tropical zone of South America, which includes the Andean region, being the area where temperatures will rise the most, with significant impacts on the performance and sustainability of the agricultural sector (Prager *et al.*, 2020). Because agricultural and forestry activities as well as changes in

1. Using our own calculations based on data from the Emergency Events Database (EM-DAT) and the IMF (World Economic Outlook, October 2022); in order to express it in relative terms, nominal GDP and population were used. Three climatological events were considered for the estimation: floods, droughts and extreme temperatures. Likewise, the events with total damage figures (valued in dollars) and affected population were taken into account, since there are events that were recorded but do not contain these two variables. All this was done following the estimate made by the Ministry of Agriculture and Forestry in October 2022. This was carried out following the calculation made by the World Bank (2009a) in "Bolivia Country Note on Climate Change Aspects in Agriculture". Sources: https://public.emdat.be/ and https://www.imf.org/en/Publications/WEO/weo-database/2022/October.
2. In its World Development Indicators, the World Bank shows that in 2020 the population exposed to floods (as a percentage of the country's total population) was high: Bolivia (15.8%), Colombia (22.8%), Ecuador (15.6%) and Peru (10.3%).

land use are responsible for about 25% of greenhouse gas (GHG) emissions, agriculture is a key player in addressing the climate challenge (World Bank, April 8, 2022).

Fortunately, the Andean countries are already getting into action through their Nationally Determined Contributions (NDCs), which include agriculture as a key sector in their adaptation strategy. While these recommendations for climate change adaptation vary from country to country, they generally emphasize the incorporation of climate change scenarios into public policy formulation, the promotion of research and adoption of new crop varieties, the encouragement of sustainable irrigation and soil rehabilitation, measures to prevent deforestation, as well as the adoption of climate-smart practices and technology. For example, Bolivia plans to restore and increase a minimum of 725 thousand hectares of degraded land for food production, and in the case of Colombia, there is an intention to reduce 26% livestock- generated GHG emissions by intervening in 25,170 farms covering an area of at least 3.6 million hectares.

The main recommendations of this chapter in the context of climate change include updating the baseline of the country's agroclimatic situation; expanding and integrating the network of agrometeorological stations to achieve regional and agroclimatic representation; incorporating census information tools; preparing a national climate change adaptation plan coordinated with other public and private agencies; adopting good agricultural practices in production chains; reviewing regulations to protect forests; reviewing mechanisms for water resource governance, management, and care; and promoting initiatives and programs for CO_2 sequestration in pastures and forests.

4.2 Climate change situation in the Andean countries

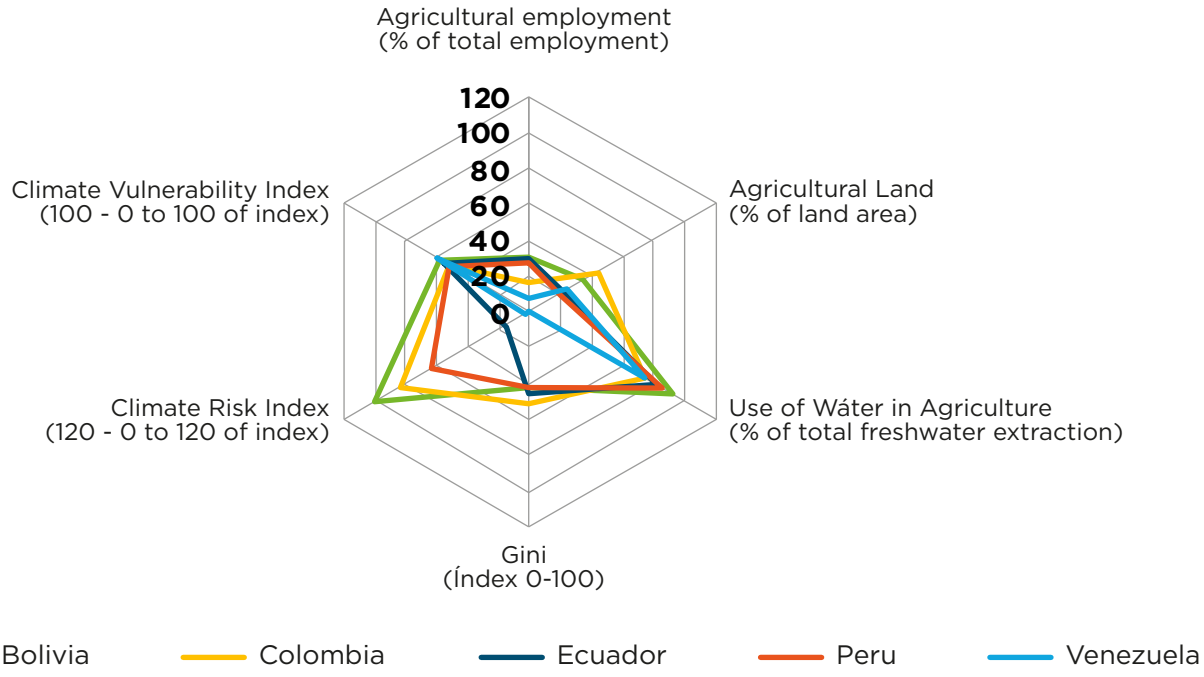
Using the most recent 2019 data from the World Bank (World Development Indicators, WDI), it can be observed that in the Andean region, around one-third of the population in Bolivia, Ecuador, and Peru is engaged in agriculture. The five Andean countries have Gini coefficients higher than 0.4, indicating high income inequality and a significant proportion of people vulnerable to poverty. Moreover, land allocated for agriculture ranges from 20% to 40% in the countries of the Andean region. Another relevant aspect is that freshwater extraction for agriculture is high in the Andean countries, ranging from 70% to over 90%. Among the Andean countries, the agricultural lands of Peru and Ecuador would be the most exposed to water stress (Standard & Poor's, 2022).

On the other hand, the Climate Vulnerability Index[3] for 2020 reported by UNDP's Climate Promise shows that Venezuela and Bolivia would be among the countries with high vulnerability, obtaining 40.0 and 41.4 points respectively on a scale of 100, placing them at positions 138 and 129 out of 182 countries analyzed (UN, 2023a). The other Andean countries would have a moderately high vulnerability, with Ecuador scoring 44.4 points (position 110); Colombia, 48.1 points (position 91); and Peru, 48.6 points (position 86). It is important to emphasize that in this index, a factor contributing to the vulnerability of these five countries is their low preparedness for adverse climate effects. Additionally, the Climate Risk Index by GermanWatch reports high risk for Bolivia, reflected in an index of 19.7 (position 10 out of 130 countries) due to significant economic and human losses. Colombia and Peru follow with high risks, having respective indices of 36.3 (position 28) and 56.3 (position 46) due to substantial human losses in both

3. This index is developed by ND-GAIN and summarizes a country's vulnerability to climate change and other global challenges. It is based on two indicators, namely "vulnerability", which measures a country's exposure, sensitivity and adaptive capacity to the negative effects of climate change, and "preparedness", which measures a country's capacity to leverage investments and convert them into adaptation actions, https://gain.nd.edu/our-work/country-index/rankings/.

countries. In the case of Ecuador, it has a low risk with an index of 103.8 (position 121), as it did not show significant human or economic losses (see Figure 4.1).

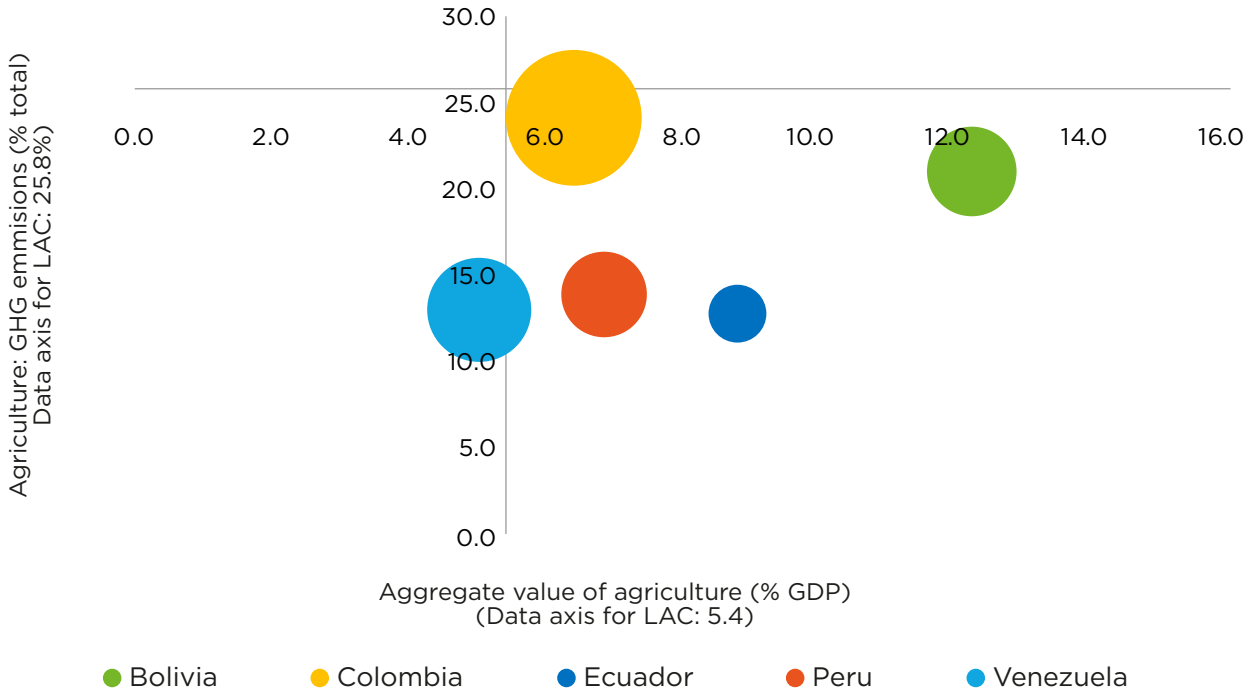
Figure 4.1. Andean countries 2019 y 2020. Vulnerability index



Sources: World Development Indicators (WDI) and Global Climate Risk Index (Germanwatch) with data for 2019, Climate Vulnerability Index with data for 2020.

There is a positive relationship between the share of agriculture in GDP and GHG emissions generated by that sector in the Andean countries. The five countries of the Andean region are close to or above the value added generated by agriculture in Latin America and the Caribbean (LAC), which is equivalent to 5.4% of GDP. Ecuador, Peru and Venezuela make a smaller contribution to GHG generation in agriculture than the regional average of 26%, while Colombia and Bolivia are close to that level. The countries where the agricultural sectors emit the most methane are Colombia and Venezuela, followed by Bolivia and Peru, and, to a lesser extent, Ecuador (see Figure 4.2).

Figure 4.2. Andean countries 2019. Contribution of agriculture to the economy and GHG emissions



Sources: World Development Indicators (WDI) and Climate Watch Data.

Note: To calculate the percentage of GHG emissions from agriculture, the Land Use Change and Forestry (LUCF) sector was considered in total emissions. The size of the bubbles indicates the amount of methane emissions from agriculture.

According to World Bank data (Country Climate and Development Report in the World Development Indicators) in 2020, of the population living below USD 5.5 per day, the percentage affected by floods was 14.7% in Bolivia, 28.2% in Colombia and 15.4% in both Ecuador and Peru. The populations most vulnerable to the impacts of climate change include people living in developing countries whose income depends directly on agriculture as one of their main economic activities. In addition, the increased frequency of extreme weather events, including rising sea levels, has had an impact on the increase in migration due to these causes. Given these situations, the number of "climate refugees" is expected to increase in the future (UNHCR, 2023).

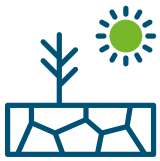
As far as agricultural land is concerned, Bolivia is characterized by permanent crops and pastures that represent 34% of the country's total land area. Arable land, which are temporary crops, could be added to this percentage and represents 4.2% of the total land area (World Bank Development Indicators). In terms of its impact on the greenhouse effect, agriculture accounts for 21% of the country's GHG emissions and land use change accounts for 56%, which are significant percentages compared to other activities, such as energy, which accounts for 19%, while the remaining 3% is due to industrial processes and waste management. Highland agriculture is mostly traditional and rainfed, which makes it more vulnerable to climate-related events. Soil erosion is a serious issue in Bolivia, with 35% to 41% of affected lands, whether from wind (35%) or water erosion (45%). Overgrazing, deforestation and improper land use are main causes of this soil erosion (World Bank, 2009a).

The population vulnerable to climate effects also represents an important segment, due to the persistence of moderate poverty in the country, which reached 36.4% in 2021, exposure to natural

disasters, droughts and floods, and a high proportion of vulnerable groups, such as indigenous people, and about a third of the employed population, who are engaged in agriculture.

As for vulnerability to the impacts of climate change, **Bolivia** is a particularly vulnerable country due to its geographic and social characteristics and the impact of climate change on its agriculture. In recent years, droughts and floods in the country have increased both in frequency and incidence. Own estimates based on the World Bank's 2009 Country Note on Climate Change Aspects in Agriculture for Bolivia (World Bank, 2009a) indicate that in recent years, floods and droughts have had the greatest human and economic impact in Bolivia. In 2016, losses accounted for 1.3% of GDP and affected 6.1% of the population, one of the highest percentages among Andean countries.[4]

In terms of GHG emissions per capita, in 2019 Bolivia reached 5.3 metric tons (t)[5], the second highest level among Andean countries after Venezuela, and close to the average data for Latin America (6.3 t) and the world (6.5 t) (ClimateWatchData, 2023).



The Andean countries are vulnerable to climate change because of their geographic and social characteristics, but also because of their lack of preparation for its impacts, with high economic and social costs for agriculture.

Agricultural in **Colombia** is responsible for 96% of all nitrous oxide (N_2O) emissions and 77% of all methane (CH4) emissions. Enteric fermentation of farm animals, land use change and forestry are responsible for 21% of all CO_2 emissions (World Bank, 2009b). According to a study on the impact of climate change on agriculture in Colombia, using climate simulations with estimated temperature increases between 2.5°C and 5°C and/or annual rainfall variations of around 10%, it was concluded that 94% of the country's agricultural production would be lost in the most pessimistic scenario (Carriquiry, 2006). Likewise, a scenario with a 10% precipitation increase would result in a 61% decrease in agricultural production, while a 10% decrease would have a positive impact of around 14.7%. On the other hand, simulations of temperature increase of 2.5 °C and 5 °C would lead to output value decreases of 13% and 31.6%, respectively.

Climate change effects also impose high levels of risk for Colombia, particularly on agricultural activity. In recent years, floods have had a strong human and economic impact in that country, reaching 3.3% of the country's total population in 2011, according to their own calculations based on data available from the Emergency Events Database[6], and entailing a high economic cost estimated at 0.7% of GDP. State studies on the vulnerability of Colombia's coastal zone indicate that 4.9% of the total area covered by crops and pastures (7.2 million hectares in total) is threatened by flooding in varying degrees. Of these, 49.5% are highly vulnerable to flooding, specifically affecting banana and African palm crops (World Bank, 2009b). Regarding GHG emissions per capita, in 2019 Colombia reached 3.7 t[7], of which 1.6 t are CO_2, a level below the average for the Latin American region and the world (ClimateWatchData, 2023).

4. Own calculations based on Emergency Events Database EM-DAT (https://public.emdat.be/), considering three climatological events: floods, droughts and extreme temperatures. Events with total damage figures (valued in dollars) and affected population were also taken into account, since there are events that were recorded but do not contain these two variables. To put it in relative terms, we used the nominal GDP and population of IMF (World Economic Outlook, October 2022) https:// www.imf.org/en/Publications/WEO/weo-database/2022/October according to the calculation made by the World Bank (2009a).
5. Measured in metric tons of carbon dioxide (CO_2) equivalent.
6. Own calculations based on Emergency Events Database EM-DAT. To put it in relative terms, nominal GDP and population from the IMF (World Economic Outlook October 2022) were used, as calculated for Bolivia by the World Bank (2009a).
7. Measured in metric tons of carbon dioxide (CO_2) equivalent.

According to the First National Communication prepared jointly with the UN on Climate Change, projections for **Ecuador** indicate that temperature would increase by between 1°C (optimistic scenario) and 2°C (pessimistic scenario), while precipitation would increase by 20% (optimistic scenario) or decrease by 15% (pessimistic scenario) by 2050.[8] According to the World Bank's World Development Indicators, 26% of Ecuador's land is used for agriculture (22% permanent crops and 4% temporary crops). Furthermore, the agricultural sector accounted for 13% of all GHG emissions, with the majority being methane emissions (70% of the total), mainly from enteric fermentation of farm animals; and land use change and forestry accounted for 61% of total GHG emissions, mainly CO_2 from forest and grassland conversion (World Bank, 2009c). It should be noted that deforestation activities have reached alarming proportions in Ecuador with an average annual net deforestation rate for the period 1990-2020 of 0.5%, the highest rate among the Andean countries and one of the highest in the region, followed by Bolivia and Venezuela (0.4%), Colombia (0.3%) and Peru (0.2%). Annual forest losses could reach between 60,000 and 360,000 hectares.[9] Besides the oil industry and timber logging, clearing of land for crops and cattle grazing is also a cause of deforestation (World Bank, 2009c).

Ecuador is also vulnerable to the effects of climate change, particularly because of its economic and social effects on agriculture, an important activity in national production. In fact, according to its own calculations[10], floods have generated the maximum loss in 2008 of 1.6% of GDP and affected 2.0% of the population. Regarding GHG emissions per capita, in 2019 the country reached 4.2 t[11], of which 2.3 t are CO_2, a lower level compared to the Latin American region and the world, but which is considerable in magnitude (ClimateWatchData, 2023).

Regarding agricultural activity in **Peru**, according to the First National Communication for the World Bank (Consejo Nacional del Ambiente, 2021), land devoted to agriculture represents only 6% of its total area (7,600,000 ha) due to the low natural soil fertility and the scarcity of water in the coastal and highland areas. Agriculture in Peru is responsible for 14% of GHG emissions and forests and land use change for 47% (ClimateWatchData, 2023). According to the National GHG Inventory, the main source of emissions is the conversion of forests and pastures (110,060 Gg CO_2 Eq.), while the main sink is the transformation of forests and other biomass wood (53,541 Gg CO_2 Eq.) (World Bank, 2009d).

Also, based on the Country Note on Climate Change Aspects of Agriculture in Peru (World Bank, 2009d), the most important crops (sugarcane, cotton, rice) are grown on the coast, using mechanized irrigation methods, while agriculture in the highlands is mostly traditional and rainfed, which makes it more vulnerable to climate-related events. Soil erosion is a very serious problem in Peru, given that only 3.3% of the country's total area is cultivated with annual and perennial crops. The most severe soil erosion problems are found in the highlands with 72% of the total land affected. Deforestation, overgrazing and inadequate cultivation practices are the main causes. Soil erosion represents 65% of the total cost of agricultural land degradation and soil salinity approximately 35% in terms of reduced crop yields associated with this damage.

8. Through the UNFCCC, the climate change unit of the UN https://unfccc.int/.
9. World Development Indicators. Measured as the average annual net change in forestation and deforestation by country. http://wdi.worldbank.org/table/3.4#. and FAO (2020).
10. Own calculations based on Emergency Events Database EM-DAT. To put it in relative terms, nominal GDP and population from IMF (*World Economic Outlook,* October 2022), as calculated for Bolivia by the World Bank (2009a).
11. Measured in metric tons of carbon dioxide (CO_2) equivalent.

The same report also notes that Peru faces serious risks due to climate change. In recent years, extreme temperatures and floods have had the greatest human and economic impact, with losses averaging 0.11% of GDP, and with 5 million people (about 18% of the country's population) affected by extreme temperatures and half a million people (2% of the population) affected by floods: these two are the highest in the region. Disaster occurrence showed an increasing trend over the years; for example, floods increased by more than 60% from 1970-1980 to 1990-2000, while landslides (mudflows) increased by almost 400% for the same period. Regarding GHG emissions per capita, Peru reached 3.1 t[12]in 2019, of which 1.8 t are CO_2, a lower level compared to 6.3 t and 6.5 t for Latin America the world, respectively (ClimateWatchData, 2023).

As for **Venezuela**, agriculture is responsible for 96.1% of the country's nitrous oxide emissions and 28.3% of methane emissions, most of which come from livestock-generated enteric fermentation. Land use change and forestry are responsible for a net absorption of CO_2 due to the natural regeneration of vegetation on abandoned land (World Bank, 2009e). Venezuela is the fourth largest per capita emitter of CO_2 in Latin America, after Mexico, Brazil and Argentina. GHG emissions per capita[13]in 2019 reached 9.0 t, of which 4.0 t corresponds to CO_2, higher than the region's 6.3 t, and even higher than the global value of 6.5 t (ClimateWatchData, 2023).

12. Measured in metric tons of carbon dioxide (CO_2) equivalent.

13. Measured in metric tons of carbon dioxide (CO_2) equivalent.

4.3 Latent challenges facing Andean agriculture

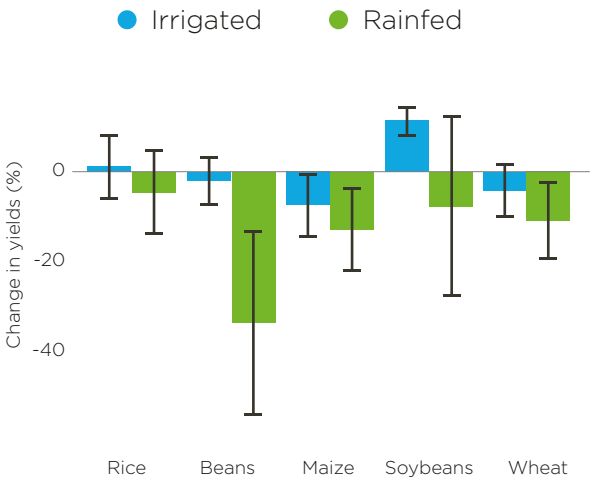
The effects of climate change include an increase in average temperature, sea level rise, intensification of extreme weather events such as droughts, floods and hurricanes, and loss of biodiversity (FAO, 2023). Several scientifically recognized studies stress the importance of taking prompt action to mitigate climate change. Among them is the renowned Stern Review, which emphasizes the benefits of early action on plans to reduce GHG emissions, estimating increasingly higher economic and social costs for as long as such reductions are delayed. The report warns that the consequences of climate change can be severe on country growth and development, ranging from health, food growing capacity, and housing to security and jobs (Stern and Stern, 2007).

Faced with higher average temperatures, essential crops such as rice, beans, wheat, maize and soybeans would be affected.

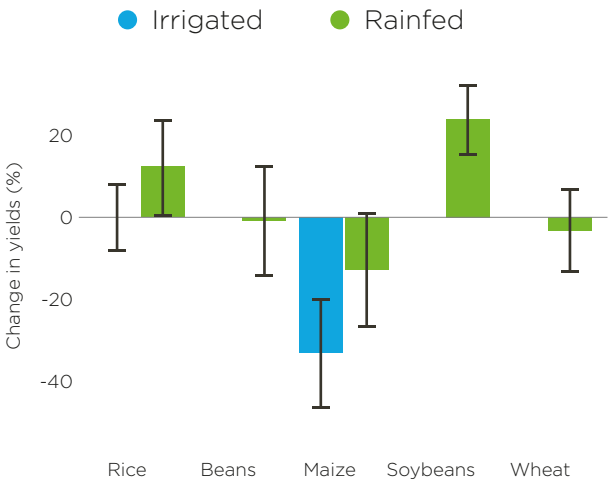
Based on general circulation models (GCM) for different LAC countries, the study by Prager *et al.* (2020) identified that climate change impacts reduce average growth in total area yields and agricultural production and increase both crop prices and trade deficits, exacerbating countries' exposure to food insecurity and falling below the critical food supply-demand ratio. The authors specifically estimated nine general circulation models and obtained projections suggesting that, throughout the LAC region, temperatures will increase between 1°C and 4°C by the year 2050. It should be noted that tropical South America is expected to warm the most, which means that yields of essential crops such as rice, beans, wheat, corn and soybeans are likely to decrease, a phenomenon that could be more severe in some regions. Furthermore, in some regions, suitable conditions for banana, coffee, and sugarcane cultivation are expected to deteriorate in some regions. In contrast, crops such as yams and cassava are expected to remain resilient in most regions. Figure 4.3 shows simulation models of the impact that climate change could have for each crop in the Andean countries by the year 2050.

Figure 4.3. Change in projected average yields of key crops (2020-2050)

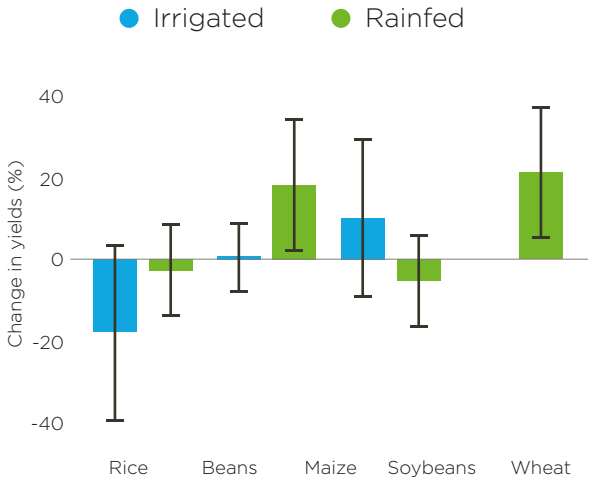
Bolivia: according to simulations, bean cultivation systems in central lowlands would be most affected.



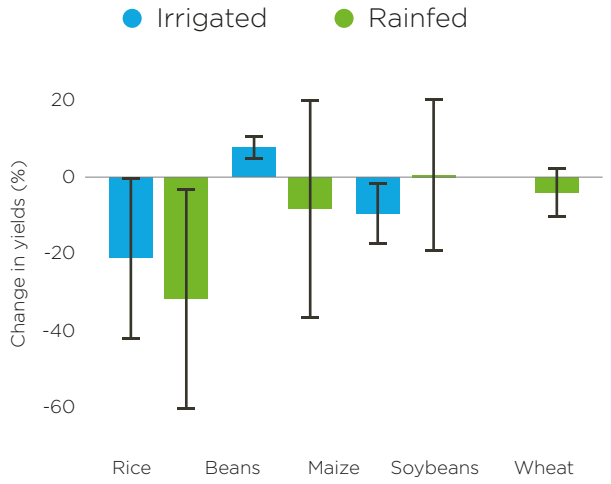
Colombia: climate change could significantly reduce maize yields, but increase those of rainfed rice and soybeans.



Ecuador: results of the crop models suggest that yields may increase for rainfed beans and soybeans and irrigated corn.



Peru: climate change could decrease rainfed and irrigated rice yields, while irrigated bean yields could increase



Source: Prager *et al.* (2020).

Note: Error bars indicate the range of production for the nine climate models. No information available for Venezuela.

In **Bolivia**, according to World Bank (2009a), temperature projections estimate an increase in the range of 0.8°C to 1.7°C by 2030 and 1°C to 2°C by 2050, with a distinction indicating that temperatures in the eastern regions will increase more, especially during the months without rain.

Rainfall projections for 2050 indicate that during dry months it will increase between 0% and 20% in the west and south, while the northwest (Pando, north of La Paz) and southeast (Santa Cruz, with subtropical forests and Chaco plains) show a greater variation and decrease in potential rainfall (-4% to 22%). However, in absolute terms, the estimated increase in rainfall is greater during the wet months, reaching up to 27 mm per month between December and March. In absolute terms, the maximum estimated increase during the dry months is 7 mm per month.

As for **Colombia**, projections made by the World Bank (2009b), with the assistance of the Japan Meteorological Research Institute, indicate that temperatures will increase between 1°C and 2°C in the high mountains, along with a significant decrease in rainfall by 2050. These climate changes will lead to the complete disappearance of snow-covered areas by 2030 and 56% of its high-altitude moorland could disappear by 2050, resulting in a loss of natural resources, especially water, with a major negative impact on agriculture. In addition, it is possible that the length of the rainy season in the San Andres Islands will increase by up to 15% by 2050 and 20% by 2080, which will increase the risk of flooding (World Bank, 2009b).

In the case of **Peru**, projections indicate increases in temperature, a reduction in rainfall, a rise in sea level and an intensification of climatic events, particularly El Niño. By 2050, the dry season temperatures are expected to increase by about 1.3 °C; dry season relative humidity is expected to decrease by 6%; the number of days with frost during the same period is expected to increase; and the ocean surface water temperature along the Peruvian coast is expected to increase by about 3 °C to 4 °C above the current level. Considerable reductions in rainfall are also projected in the north, center and south of the country of 10%, 19% and 14%, respectively.

In the case of **Venezuela**, projections made for the First National Communication indicate increases in temperature, a reduction in rainfall and an increase in areas with a dry climate. In the intermediate scenario, an increase in temperature of around 1°C to 2°C is most likely by 2060; this would have a negative impact on the biological functions of plants (photosynthesis) and on the soil's movement of water and nutrients. The decrease in rainfall will be particularly noticeable in the southern state of Bolivar, where, according to an intermediate scenario, there will be a 20% reduction by 2060 compared to the base year of 1990 (equivalent to about 800 mm less annual rainfall). A similar situation will be experienced in the area north of the Orinoco River. Other models show an intense decrease in rainfall towards the Andes and the Piemonte Plains (Piedemonte llanero). Lastly, dry climate zones, generally more prone to desertification, are likely to increase from 39% of Venezuela's total territory to 47% by 2060. This could have a strong negative impact on the agricultural sector.

4.4 Recommendations regarding climate change

In the climate change context, Nationally Determined Contributions (NDCs) in the Andean countries include agriculture as a key sector in their adaptation strategy.

Although climate change adaptation actions vary from country to country, they involve the consideration of climate change scenarios in the formulation of public policies, the promotion of research and adoption of new crop varieties, the promotion of sustainable irrigation and the recovery of degraded soils, actions to avoid deforestation, and the adoption of climate-smart practices and technology.

Agriculture is an area of mitigation prioritized by the NDCs of the four countries analyzed in the Andean region (excluding Venezuela), and is also identified as highly vulnerable to climate change (Samaniego *et al.*, 2022). Thus, using the registry of NDCs by country of the UN Climate Change Secretariat (2023b), Bolivia presents its contribution in agriculture focused on reducing food insecurity, improving yields of the main crops and soil use, recovering degraded areas, sanitizing agricultural property, with risk mitigation and climate resilience, among others. Colombia, also centered on food security, intends to contribute by improving the adaptive capacity to climate change of ten agricultural subsectors (rice, maize, potatoes, beef cattle, dairy cattle, sugarcane, cocoa, bananas, coffee and "panela-producing"sugarcane), reducing GHG emissions in livestock production, and including considerations and innovative actions for adaptation to climate change in agricultural sector planning.

Ecuador aims to implement climate-smart livestock practices at the national level to reduce GHG emissions and deforestation, and within a framework of food sovereignty that determines the implementation of public policies (regulations and norms) to integrate climate change into planning at the sectoral and local levels, as well as the development, promotion and implementation of sustainable agricultural production models and technologies that are resilient to the effects of climate change. In turn, Peru[14] aims at reducing the impact of climate change on agriculture by contributing, through soil improvement and protection, to the betterment of agricultural practices by implementing technology and risk management, in addition to managing livestock production systems to reduce GHGs and the sustainable cultivation of Amazonian crops (coffee and cocoa). In general, the recommendations include aspects such as updating the baseline of the country's agro-climatic situation; expanding and integrating agrometeorological station networks to achieve regional and agro-climatic representation; and incorporating census information instruments; preparing a national climate change adaptation plan coordinated with other public and private agencies; adopting good agricultural practices in production chains; reviewing regulations to protect forests; reviewing mechanisms for the governance, management and administration of water resources; and encouraging initiatives and programs to sequester CO_2 in grasslands and forests. It is important to clarify that all these practices are of overall importance, regardless of the climate threat. However, this threat carries with it a sense of urgency dramatically shifting priorities and timelines for action.

In the case of Bolivia and based on empirical work by Prager *et al.* (2020), specific recommendations for increasing productivity despite climate change include crop diversification, the use of improved varieties, intercropping, forest, soil and water management, developing agricultural research, and greater water use efficiency, since better use of water can include the expansion and/or rehabilitation

14. Contributions for Peru were completed with the GTM-NDC (2018) document, available at the following link: https://www.minam.gob.pe/cambioclimatico/gtm/

of irrigation systems, which is essential for their agricultural systems. In Colombia, research capacity and technology transfer aimed at small-scale agriculture should be strengthened, particularly in coastal and high-altitude regions, as well as in river basins. It is also suggested that agro-climatic and market information services be strengthened and that mitigation and adaptation goals be monitored. Regarding Ecuador, the recommendations also include better agricultural practices such as crop diversification, forest, soil and water management, agricultural research, impact assessment and resilient crops. Recommendations for Peru include strengthening agro-climatic information services and market intelligence, promoting research and adoption of specific crops tolerant to floods and droughts, as well as evaluating foods, such as yams and cassava, that would be resilient alternatives to climate change.

5

Courtesy of IDB.

GENDER EQUALITY

5. WOMEN IN ANDEAN AGRICULTURE: HOW TO PROMOTE GENDER EQUALITY AND EMPOWERMENT

5.1 Introduction

Women's participation and empowerment in agriculture is discussed in this chapter, since it is believed that there is great potential in Andean countries to develop the agricultural sector, along with quality employment and the closing of gender gaps and inequalities.

Andean women employed in agriculture represent a considerable percentage of the employed labor force. In Bolivia, 25% of employed Bolivian women are concentrated in agriculture. According to the Bolivian Employment Survey, female employment in this activity reaches 70% in rural areas (INE, 2021a). In Colombia, of the total number of women currently employed, around 6% are in agriculture, and a large part of this population lives in rural areas of the country, with 36.2% of women in this area being the predominant activity (DANE, 2022b). As for Ecuador, of the total number of employed women in the country, 25% are working in the agricultural sector (INEC, 2021), reaching 67% of the economically active female rural population in this sector ("UN Women", 2021). In Peru, 25% are also working in the agricultural sector, while nearly 80% of rural women are engaged in this activity (INEI, 2021a). As for Venezuela, female labor participation was 37% in 2021; however, there is no disaggregated data for agriculture or for rural areas (Zambrano *et al.*, 2022).

With an increase in migration of men from rural areas to urban areas, in the Andean countries there is a process of feminization of agriculture, as well as an increase in female-headed households, which in turn overburdens female domestic work. On the other hand, women in the agricultural sector in the Andean countries generally own smaller plots of land and the different ways of obtaining access to land tenure are limited, since most of the mechanisms continue to favor men, as in the case of inheritance and marriage.

In terms of gender equality, the situation of women in the Andean countries is undoubtedly unfavorable. Regarding education, two out of every three women in agriculture in Bolivia do not know how to read or write.[1] In Colombia, the illiteracy rate in rural areas among women over 14 years of age who recognize themselves as indigenous is 25.8% (Lancheros Fajardo, 2020). In Ecuador, one in four women employed in agricultural activity is illiterate (Encuesta Nacional de Empleo [ENEMDU], 2019). In Peru, 26.6% of female agricultural producers are illiterate, a rate almost triples that of male producers, at 8.9% (INEI, 2016).

With regard to the incidence of gender-based violence, physical violence in Bolivia reaches 73% in rural areas.[2] According to UN Women, about one third of the murders of women in Colombia occur in rural areas,

1. Data obtained from INE (2021b) Bolivia, and from specialist analysis taken from https://www.noticiasfides.com/nacional/sociedad/analfabetismo-dos-de-cada-tres-mujeres-agricultoras-en-bolivia-no-saben-leer-ni-escribir--411325

2. Sample data from 2016, referring to married or cohabitating women 15 years of age or older, who have lived or were living at that time situations of violence by their partner throughout their relationship (INE, 2018). 75 out of every 100 married women experienced some situation of violence (INE, 2018), based on data from the Survey on Prevalence and Characteristics of Violence against Women 2016 (also from INE).

and of the total number of sexual crimes against women, 10% were committed in rural areas (UN Women Colombia, 2015). In Ecuador, 62.8% of rural women have been victims of some type of violence in their lifetime (INEC, 2019). In Peru, 64.1% of rural women reported having been victims of some type of violence by their partner (Sanca, 2020; Observatorio nacional de la violencia contra las mujeres y los integrantes del grupo familiar, 2019).

Precisely, this unfavorable situation presents a significant opportunity to catapult the agricultural sector by empowering women engaged in this activity. As outlined in this chapter, achieving this requires reversing the current circumstances of women involved in this sector, where low economic autonomy, limited education, low land ownership rates, reduced access to financing, and lower incomes compared to men are prevalent. The main recommendations of this chapter encompass promoting the empowerment and economic autonomy of women by focusing efforts on prioritizing basic and technical education to enhance their opportunities for quality productive employment and strengthening women's associative networks and their capacity to access productive resources. Likewise, it proposes enhancing normative and regulatory frameworks in education, labor, and productive development with a gender perspective, highlighting the importance of decentralized actions, establishing responsibility links at the subregional level, and enhancing the reach of local governments, including their ability to assess and monitor outcomes.

5.2 Gender situation in the Andean countries

As will be discussed in this section, based on available indicators, the agricultural sector in the Andean countries has a high concentration of female participation in rural areas and among the indigenous population. To mention some figures, in the case of **Bolivia**, currently 25% of employed Bolivian women are concentrated in agriculture (INE, 2021a). Focusing on rural areas, it can be noted that the female population employed in the agricultural sector has remained at around 70% in the later years of the 2010-2020 decade (INE, 2021a). This amount of female employment absorbed by agriculture confirms the relevance of understanding the context and characteristics of the female population in rural areas. According to CIPCA (2015), in rural areas, women present an average of 38.10 hours worked per week in agriculture, livestock and fishing (men register 43.40 hours), taking into account this activity as the main occupation. Regarding income, it was recorded that the average monthly income of women in agriculture, livestock and fishing is 588 bolivianos; in contrast, men report 1,119 bolivians, which represents a gap of 48%.

Unlike the other Andean countries, **Colombia** has the lowest percentage of women currently employed in agriculture, with about 6% of the total number of women. However, this population resides mostly in the rural area of the country, so the participation of rural women in agricultural activities reaches 36.2% (DANE, 2022b). Rural women are a segment of the population vulnerable to restrictions on economic autonomy, since on average their income is lower than that of rural men, which is reflected in the incidence of poverty in female-headed rural households; this is 6.7 % points higher than the incidence in the male-headed population (DANE, 2022b).

In **Ecuador**, of the total number of women employed in the country, about one in four works in the agricultural sector (INEC, 2021). Women spend many more hours working than men, and this gap is even greater in rural areas. Women work on average approximately 82 hours per week, counting both paid and unpaid work, about 23 hours more than men in rural areas. In other words, on average, women

dedicate almost twelve hours a day to work, on each of the seven days of the week.[3] Among the factors that explain women's work overload are the processes of migration and urbanization that result in the feminization of agricultural work, and the persistence of gender roles that impose on women the burden of domestic work, which also implies that they are not paid for their work. In combination with this, 77.3% of rural women aged 12 and over in Ecuador do not contribute or are not affiliated to social security (Flores and Sigcha, 2020). In this context, labor precarity keeps this population without savings and highly vulnerable economically despite the strenuous hours of work they perform.

Similar to the cases of Bolivia and **Ecuador**, of the total number of employed women in Peru, one in four are working in the agricultural sector (INEI, 2021b), while, disaggregated by area, close to 80% of rural women are engaged in this activity. This amount of female employment absorbed by agriculture emphasizes the relevance of understanding the context and the particular characteristics of the female population in rural Peru in order to identify their main vulnerabilities for achieving economic autonomy. According to FAO, in Peru, the workload of women in rural areas is around 12 hours per week more than that of men; of these work hours, 61% of women's time is spent on unpaid domestic activities, while men only spend 31% of their time on this item (FAO, 2017).

Women's situation in the Andean countries is undoubtedly unfavorable in terms of gender equality. This disadvantageous situation offers a great opportunity to catapult the agricultural sector by boosting the empowerment of women working in this activity.

Based on the study by Zambrano *et al.* (2022) for **Venezuela**, female labor participation is among the lowest in Latin America and the Caribbean (LAC), at 37% in 2021. Although there are no recent official figures, it is suspected that, in line with the region, the pandemic also had a greater negative effect on women compared to men; the gender gap in labor income is estimated at between 19% and 22% (depending on the methodology applied). In terms of educational level, the most recent available data indicate that women with secondary education represent 40% versus 52% of men, and with tertiary education, 45% versus 23%, respectively. In addition, there is recent evidence of a phenomenon of feminization of poverty in the country, where the majority of heads of household are women, a factor that significantly increases the household's tendency to poverty, with a poverty rate 9.2 percentage points higher than that of men. Unfortunately, there are no disaggregated figures for the agricultural sector.

3. Own calculations, based on sample data published in Table 2 of Flores and Sigcha (2020), based in turn on the Encuesta Específica del Uso del Tiempo, conducted by INEC in 2012. According to own calculations from the same source, the gender gap compared to women, in terms of total hours worked, is around 14.5 hours in urban areas.

5.3 Autonomy and economic empowerment in the Andean agricultural sector

Women's autonomy and economic empowerment have been a priority issue on the international and regional development agenda for several years now. The Regional Conference on Women in Latin America and the Caribbean,[4] held in Quito (in 2007), Brasilia (in 2010) and recently in Santiago de Chile (in 2020), approved a number of consensus agreements through which the governments of the participating countries committed themselves to adopting a series of actions to achieve gender equality, with emphasis on women's autonomy and economic empowerment.[5] The countries of the region also reaffirmed their commitment to international treaties, instruments and resolutions on gender equality, women's empowerment and progress, including various agreements of the International Labor Organization (ILO).[6] Regional agreements were established to promote labor participation of women in STEM (Science, Technology, Engineering and Mathematics) areas, as well as to reduce the wage gap. Countries also undertook to implement countercyclical policies to mitigate the effects of economic crises and recessions on women's lives and to integrate the gender perspective into national policies for adaptation to climate change and mitigation of its effects, recognizing its differentiated impacts on women, adolescents and girls. Despite all of the above, gender conditions remain disadvantageous for women in the Andean countries.

In the current context of the Andean region, the circumstances and opportunities faced by rural women limit their economic autonomy and translate into important challenges that should be addressed when planning lines of action in the search for women's empowerment and gender equality. Among the factors that have a strong impact on this situation is the prevalence of gender roles that affects rural women in particular, which imposes a work overload on those who are engaged in agricultural activities and domestic chores, which are also unpaid. Another fundamental element is equitable access to basic productive inputs -such as physical and human capital and land ownership- which are distributed in a way that traditionally privileges men in the case of land, through systems of inheritance and marriage, and which is accentuated by the presence of conflicts, persistent illiteracy rates and even the reduced possession of identity documents among rural women, among other factors. An additional element is gender discrimination in labor reflected in salaries; and a transversal factor is indigenous identification, whose presence is significant in rural areas of the Andean countries (ILO, 2013).

Empowerment, in general, is understood as an expansion of agency (Alkire, 2005), a concept initially introduced by Amartya Sen in 1985, defined as an individual's capability to act and achieve the goals and values they consider important (Sen, 1985); in other words, the enhancement and strengthening of capacities—in this specific case, of women—that enable them to overcome barriers and constraints, specifically, to dissolve persistent gender gaps. Once agency begins to impact family, colleagues, organizations and community, it becomes empowerment. As Pick *et al.* (2007) explain, the process of

4. The Regional Conference on Women in Latin America and the Caribbean, one of the subsidiary bodies of the Economic Commission for Latin America and the Caribbean (ECLAC), is the main intergovernmental forum on women's rights and gender equality in the region. It convenes to analyze the regional situation with respect to women's autonomy and rights, present recommendations on public policies and conduct periodic evaluations of the activities carried out in compliance with regional and international agreements.

5. In 2015, the 2030 Agenda for Sustainable Development promoted by the UN was approved, which represents an important opportunity to achieve significant progress in the eradication of gender inequalities, and promotes the monitoring and creation of measurable goals, which also include in its agenda the interrelation of environmental, social and economic issues. This includes a Sustainable Development Goal (SDG) 5: "Achieve gender equality and empower all women and girls". More information on this is detailed on the official UN website https://www.unwomen.org/es/news/in-focus/ women-and-the-sdgs/sdg-5-gender-equality.

6. Four major ILO Conventions are: No. 100 on Equal Remuneration (1951), No. 111 on Discrimination in Employment (1958), No. 156 on Workers with Family Responsibilities (1981) and No. 183 on Maternity Protection (2000).

empowerment is the result of the interplay between two elements: agency and opportunity structure. If there are no real opportunities for women, empowerment will not be achieved either.

In turn, women's economic autonomy can be defined as their capacity to generate their own income and resources through access to paid work on the same terms as men. Although women's

economic autonomy is in itself a desirable goal, it is essential that, in order for it to be of good quality, it should be achieved through decent, productive work, performed in a healthy environment and free of pressures. In summary, the recommendation in this section is to promote solid economic autonomy that provides women with sufficient capacity for agency and, in turn, leads to their economic empowerment as a pillar for development.[7]

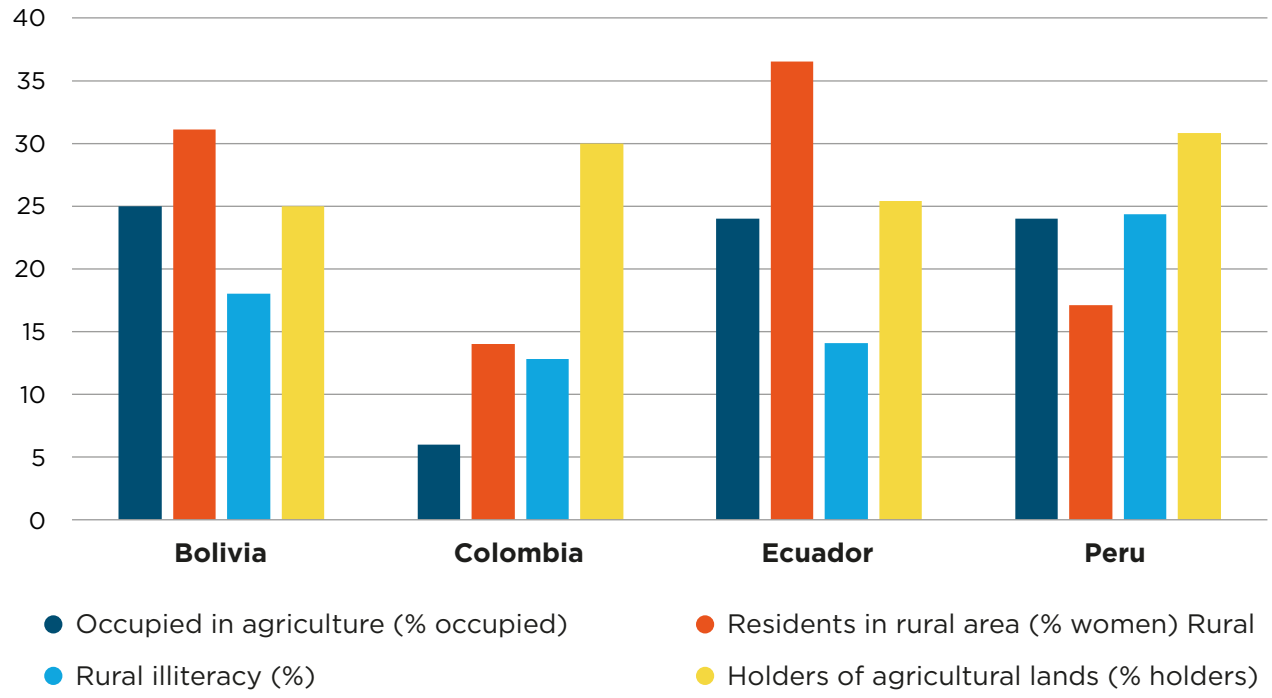
The determining factors of women's autonomy can be classified into proximal and structural factors (Itriago, to be published soon). The former refers to the provision of inputs necessary for production and income generation, where the capacity to generate income is directly associated with access to and provision of productive resources such as: physical capital, land, credit, infrastructure, technology, and even markets and information within them, among others. Complementing this, key productive resources are required, such as human capital (education and health) and social integration and social capital. The latter refer to institutional factors that determine the distribution of resources. The relevance of the institutional framework as a structural determinant of economic autonomy lies in establishing rules for the functioning of social actors, as in the case of gender roles, the modulation of social institutions into legal, political and economic institutions, and their capacity to reproduce social stratification and reinforce inequalities.

7. As can be deducted from the above, autonomy, agency and empowerment are closely related concepts that refer to a dynamic and interdependent process. In this sense, quality economic autonomy is a basic condition for agency and, as a result, for empowerment. Without real opportunities for women, empowerment will not be achieved either.

5.4 Gender challenges for Andean agriculture

Countries in the Andean region face a number of gender-related challenges regarding gender equality and social development in general.[8] Female agricultural workers and rural people in the Andean countries face significant restrictions and vulnerabilities in terms of their economic autonomy, as shown in the following table. The female population that works in agriculture or lives in rural areas in the Andean countries faces significant restrictions and vulnerabilities in terms of economic autonomy, as evidenced by the available indicators.

Figure 5.1. Andean countries: gender indicators



Sources: CIPCA (2015), FAO-Gender and Land Rights Database, INE (REDATAM, 2012), INEC (REDATAM, 2010), DANE (REDATAM, 2018), INEI (REDATAM, 2017).

A persistent challenge is the accumulation of the human capital needed to boost productivity and, consequently, the capacity to generate higher incomes. This is particularly important given the gender inequalities which, although in recent decades have been reduced, and in some cases, even eliminated -such as the gap in access to education, measured through enrollment in primary and secondary education-, there are still significant differences in terms of enrollment in higher education and STEM training.

A dimension not to be overlooked is the phenomenon of persistent gender roles in our societies that directly affect women's economic autonomy. Another fundamental aspect is access to land and land tenure, where cultural and social biases keep women at a disadvantage, as in the cases of inherited property and access to land purchase due to the lower purchasing power of this population group.

8. Detailed and disaggregated data are not available for Venezuela.

The main gender challenges in rural and agricultural areas are briefly summarized in this section, according to the availability of indicators for education, land ownership and security, in order to have a context of the conditions under which the capacities that drive women's economic independence and their opportunities determined by the circumstances they face are developed in the Andean countries.

Despite the progress made in recent years in **Bolivia**, women in rural areas continue to face important restrictions and vulnerabilities that affect their economic autonomy, particularly in the case of those employed in agriculture. For example, in education, the literacy rate, which measures access to basic fundamental skills, represents 82.7% of rural women, significantly lower than the 97% recorded for men (INE, 2021b). This implies a serious restriction on opportunities for social mobility, income generation, development of autonomy and economic independence of this population.

Land ownership is another relevant factor that perpetuates gender gaps in rural areas. In fact, a preference still remains in favor of men

when it comes to land distribution through inheritance. According to data collected by CIPCA (2017), surveyed by INE, of the total number of Agricultural Productive Units (UPAS), 75% are owned by men and 25% by women.

The economic independence of women and their opportunities are determined by the circumstances they face in terms of the availability of inputs and productive resources, and by factors that affect their distribution.

Regarding security, 64.3% of rural women in Bolivia do not fear possible displacement or loss of their land.[9] This highlights the need for sufficient guarantees of property rights and security for this population, given that the percentages are similar between women and men in the country.

Another important factor to consider is the incidence of gender-based partner violence, which, in the case of Bolivia, and based on sample data from 2016, is relatively high in rural areas, reaching 95% for psychological, 73% for physical, 53.6% for sexual and 47.1% for economic violence.[10]

In **Colombia**, the illiteracy rate of women over 14 years of age living in rural areas reaches 12.8%, a percentage that amounts to 25.8% in the case of rural women self-recognizing themselves as indigenous (Lancheros Fajardo, 2020). These relatively high levels imply an important restriction to opportunities for social mobility, income generation, development of economic independence, all of which also shows a greater lack of opportunities among indigenous populations.

Regarding land ownership, only three out of every ten landowners in rural areas are women. This structure has maintained the historical inequity observed in the country in relation to gender roles, a phenomenon that was reinforced by the armed conflict of the FARC (Revolutionary Armed Forces of Colombia), which had as central axis of violence precisely agricultural land ownership. In terms of land

9. Information received directly from the International Land Coalition (ILC) Secretariat at the International Fund for Agricultural Development (IFAD), with data from Prindex (2019), via LANDex. LanDex refers to the Global Land Governance Index (https://www.landexglobal.org/es/).

10 Sample data from 2016, referring to married or cohabitating women aged 15 years or older, who have lived or were living at that time situations of violence by their partner throughout their relationship (INE, 2018). This is 75 out of every 100 married women experienced some situation of violence; https://www.ine.gob.bo/index.php/75-de-cada-100-mujeres-casadas-vivieron-alguna- situacion-de-violencia/, based on data from the Survey on Prevalence and Characteristics of Violence against Women 2016 (also from INE).

tenure security, 66.6% of rural women in Colombia are not afraid of possible displacement or loss of their land, which is 5 percentage points less than rural men.[11]11

An important element that reflects gender inequity in the agricultural sector is the size of Agricultural Production Units (APUs) and their consequent income generation. Colombian women who are agricultural producers typically own smaller APUs, whereas men tend to have larger ones. Of the total APUs managed solely by women producers, 71.1% are less than 5 hectares in size, while among APUs larger than 5 hectares, 28.9% are managed by women compared to 40.7% managed by men (Lancheros Fajardo, 2020).

In **Ecuador**, according to data from the 2019 National Employment Survey (ENEMDU), one in four women employed in agricultural activities is illiterate. According to Ecuador's III National Agricultural Census, out of the 842,882 APUs in the country, 25.4% are owned by women producers and 74.6% by men. This is compounded by inequality in property size, mostly arising from inheritance allocation, which favors men. Among all APUs managed by women, 46.7% are less than one hectare in size, and 16.1% are less than two hectares, meaning that 62.8% of women produce on APUs smaller than two hectares.

Lastly, when analyzing the security aspect, 60.3% of rural women in Ecuador perceive security of land tenure, in terms of displacement or dispossession, and this represents 15 percentage points less than rural men.[12] This gap between women and men suggests that there is a problem of property rights that affects women more. The lack of security of rural women is not only circumscribed to the issue of their land, but also to their own integrity as individuals; in fact, 62.8% of rural women in Ecuador have been victims of some type of violence throughout their lives (INEC, 2019).

In Peru, 26.6% of agricultural women farmers are illiterate, a rate almost three times higher than that of male farmers, which is 8.9% (INEI, 2016).

Escudero's study on rural women in Peru describes that gender discrimination and difficulties in accessing land are persistent factors that negatively impact their economic autonomy (Escudero, 2020). The main way for rural communitarian women to access and have effective rights to land is through inheritance or marriage. Single women without sons or daughters do not have greater possibilities of accessing land rights and will be under the guardianship of their father or another male member of their family. In any case, these forms of access to land tenure in families are mechanisms that still privilege men. Not only are they given larger areas of land, but also those of better quality due to their location and access to water resources, which is not the case with land given to women (Escudero and Ramírez, 2020).

On the other hand, rural **Peru** has become increasingly feminized, as there is a high rate of male migration to urban areas. However, despite the fact that they are the ones who stay longer in the community, they have limited political rights. Women work the land in their families, but they make up the bulk of the unpaid occupational category. In agroindustry, when their labor is required, their wages are often lower than men's and their pregnancy and breastfeeding rights are violated (ILO, 2013).

The number of women involved in agriculture and livestock production represents about 30% of the total number of agricultural producers in the country. However, only about 20% of the agricultural area is cultivated by women and, in general, they own smaller plots of land; the average land area is 1.8 hectares for rural women, compared to 3 hectares for men. In addition, the income of rural women in Peru is low, at approximately US$134 per month, and only a small proportion of them (4.2%) are affiliated to a pension

11. Information received directly from the International Land Coalition (ILC) Secretariat at the International Fund for Agricultural Development (IFAD), with data from Prindex (2019), via LANDex.

12. Information received directly from the International Land Coalition (ILC) Secretariat at the International Fund for Agricultural Development (IFAD), with data from Prindex (2019), via LANDex.

Courtesy of IDB.

system (Escudero and Ramírez, 2020). There is also a significant wage gap between men and women, since in the agricultural sector, women earn only half of what men receive (Sanca, 2020).

Some rural women do not even have legal status, as shown by the fact that 8.2% of these lack a citizenship identification card (UN Women, 2015). 64.1% of rural women reported having been victims of some type of violence by their husband or partner and 59.6% reported having been assaulted by their husband or partner under the influence of alcohol. On the other hand, in terms of physical violence against rural women, the cases in which this generated "bruises and pain" (68.3% of the total cases of physical violence) and those of "wounds or injuries such as broken bones or burns" (14.4%) are noteworthy (Sanca, 2020) (Sanca, 2020).

5.5 Recommendations on gender

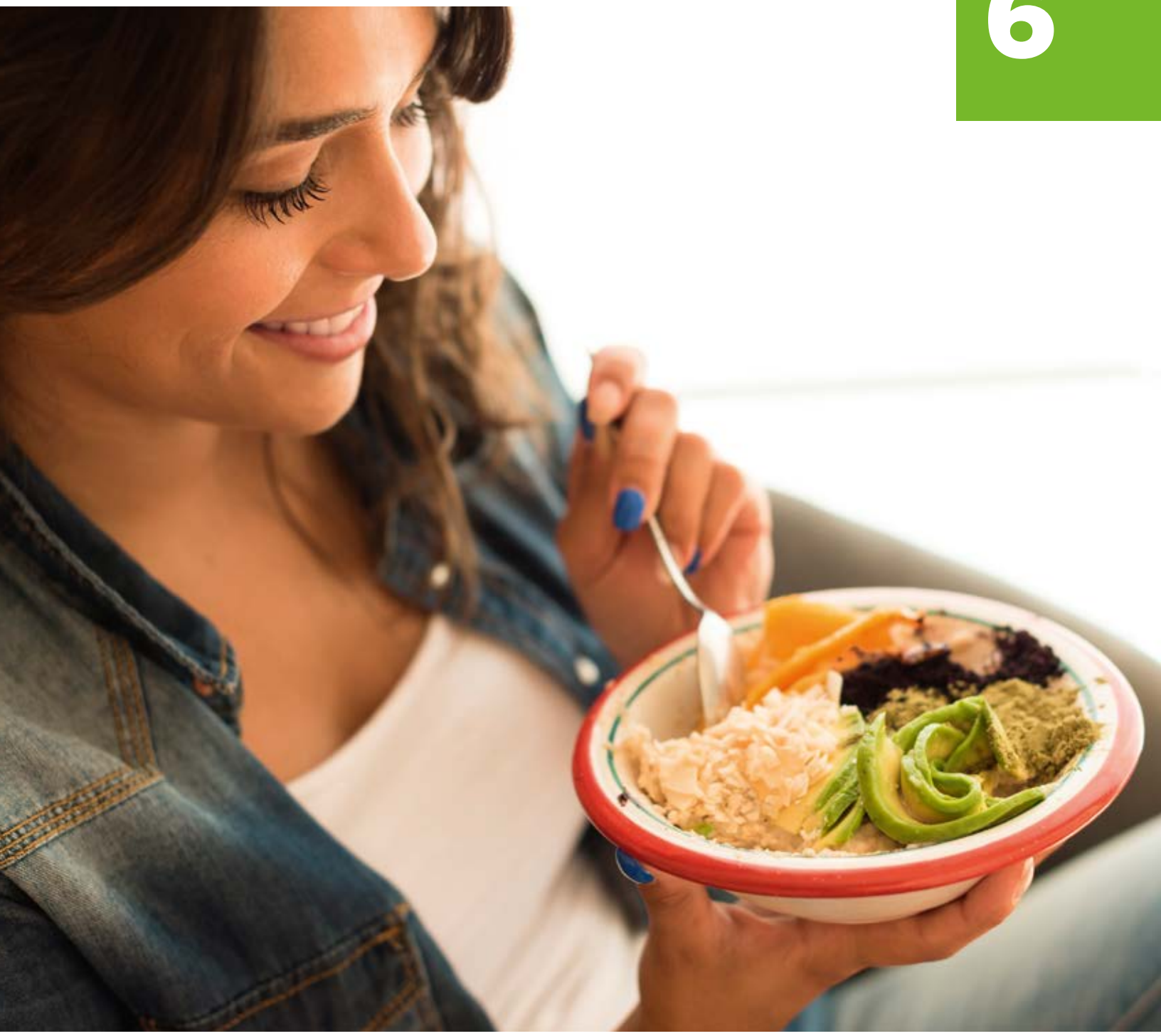
Based on the conceptual framework of the third section, the present section proposes that efforts should focus on addressing the proximal and structural constraints to women's economic autonomy, the development of their agency and corresponding empowerment, with an accurate focus on the characteristics of rural areas and agricultural activity. The primary recommendation is to promote the empowerment and economic autonomy of women in the Andean countries by addressing proximal constraints. In order to achieve this, the fundamental actions to be prioritized are the promotion of basic and technical education, which will provide women with certifiable skills and competencies to achieve greater opportunities for decent and productive employment. It is also essential to strengthen women's associative structures and their capacity to access productive resources, such as financial services and channels for marketing goods and services.

On the other hand, structural challenges require courses of action that involve changes in the legal and social rules that affect gender gaps. The institutional framework should focus on promoting the development of public policies and normative and regulatory frameworks in the fields of education, labor and productive development with a gender perspective. Ideally, these frameworks should take into consideration the specific characteristics of the agricultural sector and rural areas of each country. In this regard, the identification and practical analysis of the operation of stereotypes that limit women's access to key resources and opportunities for their economic autonomy should be promoted.

Regarding the strengthening of institutional capabilities for productive development and gender equality, it is essential to strengthen strategies and capacities with emphasis on the decentralized sphere of action as the main catalyst for achieving specific objectives and goals, first and foremost to meet the needs and demands, especially of remote rural populations. This is a key area for improvement that, through appropriate consultation and participation mechanisms, will benefit not only the target populations of social policies and their promoters, but also relevant actors in the private profit- making sector. Establishing accountability links at the decentralized level, focused on empowering, consolidating and expanding the scope of local governments, is essential for this purpose.

Intersectoral coordination and articulation is another fundamental element to enhance institutional capacities. This is important to promote a systemic and integrated management of social policies, by understanding the multidimensional characteristics of social phenomena. It is also essential at both the central and local levels to promote social development in order to achieve the objectives set at the international and national levels. Finally, it is necessary to develop the capacity to evaluate and monitor the effects generated through the application of social policy evaluation models, limited to specific programs and projects within a comprehensive support framework, which allows taking advantage of the best experiences for their potential upscaling.

6



ANDEAN SUPERFOODS

6. ANDEAN SUPERFOODS: BETTING ON NICHES THAT ARE HIGHLY VALUED IN THE WORLD MARKET.

6.1 Introduction

Superfoods, named for their exceptional intrinsic nutritional characteristics, which the Andean countries have been producing for some time, represent a genuine opportunity to boost export production chains and penetrate emerging market niches, given the growing demand for healthy and nutritious foods and their global revaluation. This should be pursued within a framework of sustainable and inclusive productive development that promotes productivity under the best livelihood conditions for farmers and in harmony with the environment.

As described in this chapter, Andean countries have natural comparative advantages for producing these superfoods owing to a range of factors, such as their fortunate topography, geography and agroecological conditions that have an impact on genetics and varietal richness, including the existence of native varieties. Additionally, there are other comparative advantages enjoyed by some of them, either due to low production costs, their high quality and recognized diversification of the product, their ecological production and, in some cases, even tariff preferences. Indeed, the virtues of these superfoods extend beyond their nutritional qualities, since in many instances they also have ecological attributes and productive cultivation qualities that allow their production in harmony with the conservation of forests and the Amazon. For example, the Amazon nut crop requires no pesticides, fertilizers or any other chemical compound. Another example is sesame, a crop that can even thrive in dry and infertile soil areas, requiring little investment and technology. In addition, many of these crops have an important socioeconomic impact in terms of job creation and income generation for indigenous and peasant communities, as well as various production sectors from small growers to large consolidated companies.

Success stories are also briefly described in this chapter, emphasizing the most important factors that have made them successful, ranging from good business practices to product differentiation strategies, key chain linkages and effective synergies. Challenges faced jointly and also on a case-by- case basis, lessons learned, as well as areas of opportunity that can be exploited to strengthen the sector for each superfood and as a niche in general are also described. In short, the objective of this chapter is to provide an overview of the immense and genuine opportunity that the Andean countries have ahead for developing the superfoods sector in a strategic, inclusive and sustainable manner for the benefit of their economies and the welfare of their people. Details on each superfood are available in the studies cited for each case.

6.2 Potential of Andean superfoods

This section presents the main superfoods in alphabetical order by country. Occasionally, when the product is repeated in another country, this will be included as well.

AMAZON NUT
The world's leading exporter with 82% of total production, it generates 75% of the income of the northern Amazon and employs 13,500 families.

Amazon nut (Hidalgo, 2021b). **Bolivia** is currently the world's leading exporter of Amazon nut, also known as Brazil nut. It accounts for 82% of world production, surpassing even Brazil, where potential extraction area is much larger. It is worth noting that this wild product (since it cannot be cultivated) has formed the most important development base in the northern Bolivian Amazon region, generating 75% of its income and employing 5,000 families during the harvest season and more than 8,500 families in the shelling and roasting processes. It is also the second most important non-traditional national product after soybeans in terms of exports, accounting for 98% of its production, i.e. only 2% is sold on the domestic market.[1] Because of its intrinsic organic and nutritional characteristics, the Amazon nut is considered a superfood with great international market potential; it has a remarkable biological contribution, as it does not cause damage to forests and is a crop that requires no pesticides, fertilizers or any chemical compound.

The success of this sector in Bolivia is due to good coordination between private initiative and public policies aimed at its development. The productive base formed by the regional concentration of this activity allowed an early articulation that was consolidated in 1993 with the creation of CADEXNOR (Cámara de Exportadores del Noroeste) and IBNORCA (Instituto Boliviano de Normalización y Calidad). This allowed establishing an effective synergy between the private sector and the government, reducing quality control costs and capitalizing on the private sector's knowledge of the market to focus regulations on the needs and demands of the end customer. Bolivia has developed its own certification processes based on international standards, including organic crops, product quality and forestry management. On the other hand, in 2009, the Empresa Boliviana de Almendra y Derivados (EBA), a state-owned company whose purpose is to promote the development of the chestnut sector, was created. Similarly, in 2013, EBA Europe was founded in the city of Hamburg, a branch dedicated exclusively to the distribution of Amazon nuts in Europe.

Peanut (Zeballos, 2021). After Brazil, Argentina and Paraguay, **Bolivia** is the fourth largest producer of peanuts, also known as groundnuts, in the region. Small-scale Bolivian cultivation of the product is managed by 17,800 farming families, 95% concentrated in three departments (Tarija, Santa Cruz and Chuquisaca) with a national production of 28,300 t (2019) generating USD 15.5 million per year; 55% from domestic marketing and 45% from exports. Since 2010, peanut exports have quintupled, reaching USD 10.7 million in 2019; **Peru** is the main destination market. The success of peanut exports is due to its nutritional properties; the World Health Organization (WHO) recommends it among legumes for a healthy diet (WHO, S/F); likewise, the Food and Agriculture Organization of the United Nations (FAO)

1. The low consumption in the local market is in the form of direct consumption or snacks and as an input in the manufacture of panettones, cakes, cookies; also as cooking ingredients and as part of the breastfeeding subsidy.

highlights its high energy value, rich in healthy oil and protein (FAO, S/F). In addition, recent scientific research provides evidence of other benefits for cardiovascular health (Luu *et al.*, 2015). On the other hand, peanut cultivation has many advantages, as it shows drought resistance (Technical Unit of the DELNO (1977) project), grows in low fertility soils and is an option for crop rotation; these last two factors apply mainly in the case of Bolivia (Perez and Garcia, 2015).

PEANUTS
It generates USD 16 million per year and employs 17,800 native rural families.

Success stories include the companies AGRINUTS S.A. and APROMAM S.R.L. AGRINUTS, founded in 2010 in the department of Santa Cruz, with the vision to identify the potential of native Bolivian peanuts for export to Europe, employing medium-sized growers interested in adopting technical criteria. Other key elements included its partnership with the Argentine company CABSA, with expertise in peanut cultivation, which introduced its own seed of the Runner variety, the most demanded internationally and which to date represents 90% of its total production. Its successful results are the product of its plant processing operations, good management practices for quality, commercial and financial administration, as well as its focus on small and medium-sized international customers. This has enabled it to penetrate fifteen new markets[2], with exports of 2,175 t in 2019. Furthermore, thanks to Fundación Valles, which provides technical support to small peanut growers, the APROMAM association was created in 2012, which from its beginnings integrated 380 growers from Cochabamba and Chuquisaca, specializing in the sustainable cultivation of certified organic peanuts, exporting 75% (40 MT) of its production to Germany since 2013.

QUINOA
Both countries lead world production (Bolivia 47% and Peru 50%), and together they export 80% of the total and employ 122,000 small growers.

Quinoa (Valdivia *et al.*, 2002). To date, **Bolivia** and **Peru** represent the center of world quinoa production with 98% of the total produced: Bolivia with a 47% share and Peru with 50%. Together, both countries account for 80% of world exports. It should be noted that Peru specializes in the production of sweet quinoa with almost double the productivity (1,296 t/ha)[3] compared to Bolivia (0.65 t/ha), which cultivates 60% quinoa Real[4] and 40% sweet quinoa.[5] The quinoa sector in both countries involves 122,000 small growers in peasant communities: 54,000 in Bolivia and 68,000 in Peru.

2. Russia, Ukraine, Vietnam, several European Union countries, and Colombia, Ecuador, and Chile.
3. Factors driving Peru's higher productivity are: i) quinoa variety; ii) technological packages; iii) soil fertility; iv) agro-climatological factors; and v) improved public goods.
4. Quinoa Real is a variety grown in the Southern Altiplano of Bolivia, characterized by the bitterness of the seeds. They are exceptionally large in size and of different colors, being the only variety in which seeds are black (Tapia, 1979).
5. In the case of the Bolivian Royal Quinoa, its quality and qualities have been recognized by obtaining a denomination of origin, both nationally and by the Andean Community of Nations (CAN); in turn, NASA included it as food for astronauts.

Noteworthy are the exceptional nutritional properties of quinoa, listed by FAO in 2013 as one of the most prominent crops of humanity for its attributes in combating malnutrition.[6] It is also a crucial crop for food security and climate adaptability, due to its resilience to low rainfall and temperatures.

Success cases of ANAPQUI and ANDEAN VALLEY CORPORATION in Bolivia and WIRACCOCHA in Peru are outstanding for creating favorable productive ecosystems for the sector in general. Small associated growers or suppliers have improved productivity and increased their share of profits through the direct and indirect involvement of these companies in the entire value chain (production, processing and marketing) of certified organic quinoa and value-added products derived from it. This was particularly achieved by providing growers with inputs (mainly certified seed), technical and financial assistance, as well as through links with the government, resulting in tangible results in terms of legislation, financing, technical assistance and research. Success has also been due to working with private players in terms of technical assistance and financial resources, as well as international trade agreements and alliances. Positioning the health properties of quinoa worldwide has been another key factor for these companies.

Sesame (Hidalgo, 2021a). Sesame has a major socioeconomic impact on the economy of small farmers and indigenous, intercultural and peasant communities in **Bolivia**, employing at least 4,000 families. The growing global demand for this superfood is explained by its high content of calcium, vegetable protein and phytic acid, known as a potent inhibitor of colon cancer cells. In addition to its nutritional advantages, it has outstanding productive advantages due to its low investment, soil fertility and technology requirements, and can be grown in dry areas. In 2020, exports registered a record of nearly USD 18 million, due to the growing demand from China for the black sesame variant and the opening of the Japanese market. The department of Santa Cruz accounts for 99% of the total agricultural area, making Bolivia the fourth largest producer in South America.

SESAME
Fourth largest producer in South America, with a record export of USD 18 million in 2020.

Agroexportaciones del Sur S.R.L. (AGROEXPORT), created in 2005 and specializing in the production, processing and international marketing of sesame, is a success story. Its exports reached 60% (7,500 t) of total Bolivian exports of this seed in 2020. The key to its success lies in its differential supply of high-quality seeds, in addition to its professional managerial and technical human resources[7], its international certifications and its traceable production program[8].

6. For more information, see Launch of the International Year of Quinoa (FAO), https://www.fao.org/quinoa-2013/press- room/news/detail/en/detail/en/
7. With previous experience in the pioneering company Bolsemillas, which in 2002 succeeded in introducing high-quality sesame to the Japanese market, where the counterpart is the company ITOCHU, which, in turn, has contributed to improving quality processes by informing AGROEXPORT about the needs of its customers in terms of pesticide control, purity, appearance, flavor, among others.
8. It is linked primarily with small growers by providing seed, training, technical support, follow-up and financing.

Avocado/palta (Pérez and Gómez, 2022). The international avocado market has quadrupled its value in the last decade driven by new consumers around the world, who are inclined to healthy consumption, increasing demand and leading to a rapid growth of this industry. In response to this increased demand, some Latin American countries have bet on avocado exports, as in the case of **Colombia**, which in just seven years managed to export more than USD 146 million, starting from having no presence in the international market. **Peru** has managed to multiply its exports more than tenfold in the last fifteen years and is currently the second largest exporter in the world after Mexico. In both countries, this industry continues to expand and is a source of new jobs and investments, benefiting from their climatic characteristics that allow at least two harvests per year, increasing productivity and competitiveness compared to other regions.

AVOCADO

Peru is the world's second largest exporter (2018, USD 716.7 million). Colombia employed 54,000 workers in 2020.

Adequate policy guidelines that allowed the consolidation of target markets through a commercial approach have been among the driving forces behind this industry in Colombia. Likewise, the role of the Colombian Agricultural Institute (ICA) and ProColombia in promoting the industry has been crucial in providing technical support and expanding trade relations. The positive effects of the Peace Agreement (2016)[9] on connectivity, productivity and expansion of the agricultural sector should also be highlighted. On the other hand, the favorable institutional context in Peru allowed it to access greater export volumes and destinations through free trade agreements. In addition, its adequate promotion of the agricultural industry, through Peru's National Agricultural Health Service (SENASA)[10] and the Agricultural Promotion Law (2000),[11] led to 27% of the country's formal jobs being generated by agriculture. This favorable context for the industry made it possible to achieve vertical integration success stories that increased the associativity between packing and exporting companies, which increased considerably in number due to the industry's performance, even with state participation.

9. The Final Peace Agreement designed to put an end to the conflict between the Colombian State and the former FARC (Revolutionary Armed Forces of Colombia) guerrillas, whose first item is the Comprehensive Rural Reform, aimed at resolving conflicts arising from land ownership and use.

10. Through commercial efforts and its cooperation with producers, it boosted international trade and managed to position Peruvian fruit as a quality product, particularly in terms of pest management.

11. This law established a special tax and labor regime and was renewed in 2006 and remains in effect until 2021.

Cacao or cocoa (Villacis *et al.* 2022 and Clemente 2022). The Andean region has a comparative advantage for cocoa cultivation due to its fortunate geographical position which impacts on aspects such as genetics and diversity, allowing it to concentrate seven of the eleven genetic groups of cocoa. It is worth noting that cocoa is a product with high agroindustry potential, due to its broad value chain, which begins with the production of basic products, such as cocoa butter, to the production of chocolates and sophisticated derivatives used in a variety of industries. The region is currently responsible for 90% of the global production of fine cocoa, which is used in the manufacturing of high value- added products, and its production has been steadily increasing, quadrupling between 2000 and 2020. Despite all of the above, nine out of ten businesses in this industry are held by small producers and low-productivity family agriculture.

COCOA

Ecuador is the world's leading producer and exporter of the "Fino de Aroma" variety, and employs 100,000 producers (85% small-scale).

Venezuela: exports 40% of total production of "high quality aromatic" cocoa, and employs 16,505 producers (90% small-scale).

Cocoa bean production is strategic for **Ecuador's** economy, as 90% is destined for export, making it the third largest generator of income from non-oil exports, reaching USD 657 million in 2019. It is also grown in 21 of the country's 24 provinces mainly by small producers, with no problems related to deforestation or child labor, creating at least 600,000 direct jobs. Ecuador is also the genetic center and main producer and exporter of the national variety Fino de Aroma, highly valued for its gourmet attributes of flavor and aroma, which represents between 6% and 8% of the world's cocoa production (Clemente, 2022).

Two companies stand out for their business model based on product differentiation with an emphasis on quality. The first is Corporación Fortaleza del Valle (CFV), a farmers' association founded in 2006, dedicated to cocoa bean production. The second is Pacari Chocolates, a company established in 2002 that works with farmer associations to produce chocolates. From the very beginning, both companies focused their attention on the growing world demand for cocoa with "credential attributes", i.e., recognized high quality and organic production, in addition to supplying the gourmet chocolate markets, intervening in the entire Fino de Aroma cocoa value chain. They also obtained a designation of origin and organic and fair-trade certifications; established quality monitoring and control in post-harvest stages; invested in product innovation; and used direct channels to markets. CFV has a sustainable production system with an emphasis on economies of scale, constant support for producers in financial matters, input supply, and technical assistance and training, all while being environmentally friendly. CFV generates annual sales of US$2.8 million, with Switzerland being its main market, while Pacari, winner of more than 300 international chocolate awards, has annual sales of between US$15 and US$20 million.

Cacao production in **Venezuela** has a long tradition in the country, dating back to the 16th century. However, its contribution to world production is currently marginal, with a 0.35% share, and the country's producing regions generally suffer from high levels of poverty, limited diversification of economic activities and restricted access to basic services. The country's economic crisis has impacted commodity processing companies, and cocoa has been no exception. Worthy of mention is that, in the face of adversity, these companies have vertically integrated upstream, creating their own access to inputs to produce and secure their supplies. They have also achieved downstream integration in industrial processes, taking advantage

of the Productive Integration Programs (PIP), with associations linked to input and/or service companies, articulation with state governments and industries, and ties with cereal marketing intermediaries.

Pitahaya/dragon fruit (Barrera *et al.*, 2022a). **Ecuador** recently became a major producer and exporter of pitahaya, also known as dragon fruit. Between 2005 and 2019, both the volume and value of its exports increased by about 80%. Pitahaya is an exotic tropical fruit native to Central America, which began to be cultivated in Ecuador in 1994 among a small group of farmers, quickly gaining notoriety as a profitable alternative to replace staple crops such as corn, rice and bananas. The country produces two varieties, red and yellow; within the latter are varieties such as Palora and Pichincha, which are mainly exported. Characteristics that distinguish its production in Ecuador compared to other competing countries include size, softness, sweetness, aroma, shape and color.

PITAHAYA

Its niche market is China. Its value chain employs 624 growers (90% small) and another 10,780 people in the other links.

Of total domestic production, 45% is destined for export; however, between 20% and 40% of all fruit sold by growers to exporters is rejected for failing to meet quality standards. Rejected fruit is sold together with product destined for the domestic market or traded informally with other countries. The value chain for this fruit has several intermediaries in the domestic market, which has a positive socioeconomic impact upon intermediary traders. It should be mentioned that there are a handful of companies that have successfully managed to stand out for having integrated production, packaging and exporting. These exporters have found a niche that guarantees their product supply, consolidating destination markets and differentiating their product through international certifications of good practices and organic products.

Blackberries (Barrera *et al.*, 2022b). Blackberry production in Ecuador has been a tradition for decades, based on small-scale family farming, with 5,300 national growers concentrated in three provinces, namely Bolívar, Tungurahua and Cotopaxi. Production is mainly destined for the domestic market, with a low export level of only 0.5% of total production.[12]

This is attributable to problems in the blackberry value chain that manifest in different ways, starting with insufficient supply to meet domestic demand,[13] which is covered by imports from Colombia. Likewise, productivity is low (6.8 t/ha) compared to Colombia (10 t/ha) and Mexico (15 t/ha), two countries with significant blackberry exports in the region.

12. In 2019, Ecuador exported only 38 tons of fresh blackberries and 51 tons of frozen blackberries, valued at USD 67,000 and USD 131,000, respectively.

13. Most of the blackberry production, approximately 34,000 t, is consumed in the domestic market; however, this level is insufficient to cover domestic demand of around 40,880 t.

A natural advantage of Ecuador is that it produces blackberries all year round, in contrast to other producing countries. Faced with a growing world demand for blackberries due to their nutritional and organoleptic properties[14] and culinary qualities, northern hemisphere countries show a particularly high demand for this berry.

BLACKBERRY

Its niche market is the U.S.A. due to its very competitive production costs. It employs 5,300 growers (family farming).

Blueberries (Ghezzi and Stein, 2021). **Peru** has set a benchmark in agricultural exports with blueberries, since it grew from exporting USD 0 to over 1 billion between 2014 and an exceptional advantage of Peruvian production is that its climate allows it to produce all year round and to take advantage of price cycles, due to the variability of world supply, in order to increase its profits. Fresh blueberries are valued about four times more than "discarded" product and are the main focus of Peruvian exports. 2020, and is now the largest exporter in the world. was possible due to the right combination of exceptional conditions for blueberry production[15], with a favorable business climate, a very professional private sector and, above all, a set of good public policies.

BLUEBERRIES

From producing nothing in 2014, Peru is now the world's largest exporter with USD 1 billion in 2020.

This combination of good public policies and favorable climatic conditions has been a determining factor. Investments in land-parceling and irrigation projects made previously desert lands available for agriculture during the last decades of the twentieth century. Institutional efforts also helped to boost Peru's export boom through trade policies that consolidated markets by means of free trade agreements and the opening up to new destinations, as well as the negotiation of tariffs and phytosanitary barriers through SENASA, in addition to labor conditions and tax benefits provided by the Agrarian Promotion Law of 2000. The advantages of this law regarding the flexibility of fixed-term labor contracts, which, unlike the general labor regime, reduce the cost of seasonal worker turnover between crops, benefit both production and the generation of formal employment for low-skilled labor.

These conditions attracted the attention of investors and alliances with foreign universities, which led to the genetic development of four local varieties, including Biloxi, and the development of large export companies that were able to consolidate their position in the global market, strengthened by their vertical integration from cultivation to market penetration.

14. Food characteristics that can be perceived by the senses include: color, flavor, smell and texture.

15. Noteworthy are climatic conditions with stable temperature and favorable luminosity due to proximity to the equator, mitigated agricultural risk to cross contamination and frost, vast extensions of available land, and high productivity marked by extremely short periods for bush growth, which allows the development of new varieties to be evaluated.

TUNA
Exports of USD 15 million in 2021.

Tuna (Penfold, forthcoming). The tuna sector used to be the strongest chain within the entire **Venezuelan** fishing sector due to advantages such as the abundance of the resource on its coasts, its high levels of industrialization, the quality of its marine fleet, its great export capacity and potential, and its high domestic demand. However, this sector has been one of the most severely affected by the implementation of price controls, which lasted more than ten years, and by the legal and regulatory bias of the Fishing Law. Both aspects, together with the elimination of fuel subsidies, affected the sector to the point that it had to close its commercial activity in a large portion of the country, with the consequent complete dismantling of the industrial activity. As a result, tuna fishing in Venezuela declined sharply, as did sales in the domestic market.

While the country had traditionally focused on the domestic market, in recent years' Venezuelan tuna producers have concentrated their activity abroad. Unfortunately, the various internationalization efforts have failed for several reasons, but mainly due to the lack of investment and the difficulty to access global markets. Despite these adversities, however, it should be noted that the sector managed to adapt to regulatory and institutional obstacles in a very peculiar way. On the one hand, companies took advantage of foreign exchange controls to subsidize investment in the modernization of their marine fleet. On the other hand, they moved fishing to the Pacific coast of neighboring countries. This was accomplished by taking advantage of the agreements of the Inter-American Tropical Tuna Convention (IATTC), which allows fishing in other waters of the region, and where they took advantage of fuel subsidies to enhance their competitiveness.

COFFEE
It employs 300,000 small growers, and the main type it produces is arabica, which is highly valued internationally and with export potential.

Coffee (Clemente, 2022). South America currently accounts for 48% of world coffee production, most of which is of the arabica variety, which is of higher quality than robusta grown in most of Asia. While quality is a highly valued characteristic in the market, the arabica variety presents a high variability in its production due to its greater susceptibility to climatic changes and specific coffee diseases such as rust. All of the above has repercussions on the socioeconomic problems of its growers, as its production is affected and its price fluctuates. This situation has in fact encouraged investment in potential new varieties that would offer a balance between hardiness and quality.

Coffee growing in **Venezuela** has been the driving force that energized the national economy before the oil boom, displacing other traditional crops, such as cocoa, from the beginning of the XIX century until the middle of the XX century. The country grows mainly Arabica coffee, and 90% of its growers are small farmers. Most of the country's production is currently destined for the domestic market. The influence of its cultivation and commercialization in the development of the country has been of such magnitude that it has contributed to the opening of highways and the consolidation of urban centers in coffee growing areas. Although

its production has quadrupled from 1960 to the present, in the last ten years it has suffered a sharp drop due to climatic factors, rust and increasingly higher transactional costs as a result of the country's inflation. In spite of these climatic and economic adversities, the coffee industry has managed to integrate vertically upstream, achieving a greater connection between the commercialization and supply sides of the production chain. On the other hand, it is still disarticulated along its value chain due to the high level of informality and low productivity of the intermediation and post-harvest links, and to the high concentration of the sector in its industrial stage, which has reduced the number of companies with greater capacity for vertical integration.

Shrimp (Penfold, to be published soon). With 2,850 km of coastline on the Caribbean Sea, **Venezuela** undoubtedly has natural comparative advantages to develop the growth of the shrimp industry. Despite these favorable geographic conditions, it was not until the early 1990s that this sector began to emerge and is now the most important non-oil export production chain in the country, surpassing even traditional mining sectors in terms of performance. In fact, shrimp exports tripled in the last decade, and its productivity is among the highest in Latin America, offering very attractive profit margins for foreign investment.

SHRIMP
The country's most important non-oil export production chain, with USD 500 million in exports in 2021

As the shrimp industry concentrated its activities on exports, local companies were able to significantly increase their competitiveness. The success factor was exposure to the higher standards demanded by the international market. This, in turn, created a virtuous circle, attracting additional early investments in the industry in order to ensure the quality of naturally nutrient-enriched water, decreasing the incidence of diseases and maintaining adequate shrimp density. These investments also contributed to increased productivity through the leakage of technology transfers to other local producers. Another key aspect of success has been the ability to shield export operations from the constant institutional changes in the domestic market, the energy crisis and the country's regulatory risk. In addition, a crucial factor has been the resilience of the sector and its ability to adapt to a context of unfavorable prices and government subsidy cuts, a condition that has attracted more foreign investment in the industry, thus consolidating it.

6.3 Main challenges facing Andean superfoods

Courtesy IDB

The most outstanding challenges faced by each superfood production chain in the Andean countries are presented below, in alphabetical order by country. Although each crop or superfood has its own particular characteristics, in addition to the idiosyncrasies and context of each country, it is also true that many of these challenges are shared. A common challenge present in this niche of Andean superfoods is the lack of adequate financial sources, instruments and formal mechanisms for small-scale producers to cover their financial needs for various purposes, ranging from the purchase of inputs to investment in innovation and technology.

Other common challenges are: technological adoption and upgrading, access to training and technical advice to increase production and productivity, consolidate a quality exportable supply and reduce production costs. Likewise, the lack of associativity, coordination and integration between the links in the value chain, leading to production chains, vertical integration, clusters, value chains, among others, limits potential benefits, including greater bargaining power for producers when dealing with input suppliers and intermediaries, spread of knowledge and good practices (e.g., for pest control or the use of pesticides and fertilizers, among others), taking advantage of economies of scale, the creation of value added and the development of regional hubs.

Another shared challenge is obtaining certifications (e.g., environmental, organic, quality), recognitions (e.g., designation of origin), and a traceability system for the production chain in order to access and compete in international markets, where superfoods are more highly valued. Also highlighted are the institutional framework and public goods provision as barriers to the sustainable and inclusive productive development of the chains of various superfoods. It is crucial to have an institutional framework that provides a regulatory and legal framework, with appropriate incentives and mechanisms for the development of sustainable enterprises, their incorporation into formal local and international value chains and financing mechanisms (e.g., first-tier development banks).

In turn, the provision of basic public services is required for a range of important aspects, including energy provision, pest control, investment and phytosanitary regulations, resilience to climate change, caring for the environment and benefiting the populations associated to crop production. Finally, it should be noted that the combination of barriers has, in turn, a negative impact. For instance, the lack of access to financing for investment in research and innovation hinders the development of new pest- resistant crop varieties.

The main challenges facing the Amazon nut sector in Bolivia are related to production and export limitations. In terms of production, the lack of investment and limited access to financing for small producers means that loans are informal or even granted by foreign entities due to the lack of local financial capacity. Unsatisfied financing needs, especially at harvest time, mean that domestic production is well below its potential. On the other hand, penetrating new markets is a challenge, which requires

a greater marketing effort to negotiate tariffs and investment in public goods and logistics. Another challenge has to do with providing electricity, since this region of northern Bolivia is part of an isolated electrical system that is not interconnected to the main power grid, which is necessary for refrigeration facilities to preserve the product as part of the export chain.

The main challenges in the case of peanuts in Bolivia include, in first place, overcoming the low levels of technology adoption, the lack of access to financing faced by small-scale rural producers, the lack of training and technical assistance, and the prevalence of small-scale plantings that limits the development of efficient technification processes. In terms of government policy, while there is a law that assigns peanuts a national priority status, concrete actions are needed to develop a peanut cluster, following the experience of Brazil and Argentina, the largest peanut producers in the region.

In Bolivia and Peru, quinoa faces its own challenges. The first challenge facing the quinoa value chain is linked to associative deficiencies that persist among growers, restricting their bargaining power due to the low volumes being offered, which makes it necessary to promote the development of a production cluster. Another challenge is climate change and its adverse effects on the water cycle by exposing production regions to more extreme drought situations, making it essential to invest in irrigation infrastructure. Regarding origin designation, it is necessary to promote this certification for other varieties such as quinoa from the Andes, which involves hard work and management to achieve it. Finally, given that organic, environmental, fair price and quality certifications have been obtained, there is still the challenge of expanding these and obtaining others in order to access markets that pay a higher price for the product.

Current challenges for sesame in Bolivia include aspects such as the low financial capacity of small farmers, who are highly dependent on exporters for financing; the lack of access to training and technical assistance, especially for disease control; and bottlenecks for developing new competitive varieties for planting and harvesting in larger areas. Finally, the effects of climate change pose a challenge when it comes to addressing its impact on rainfall patterns and the redefinition of new production zones.

Among the challenges faced by the avocado industry in Colombia and Peru are the bottlenecks to achieving environmental certification and taking advantage of additional markets. Another challenge is to improve financial penetration for small and medium-sized growers, which is still scarce and necessary to consolidate the strengthening of the sector. In fact, this is important for the sector to be able to coordinate efforts and avoid fragmentation between large capitals and small and medium-sized producers, so that the benefits can be fairly reaped. In this regard, the national government has the opportunity to lead the integration of efforts by applying the lessons learned from the coffee experience.

Regarding cocoa challenges in Ecuador and Venezuela, cadmium present in cocoa and its Fino de Aroma variety in the case of Ecuador needs to be addressed, since its production would be affected by the new European regulation that establishes concentration limits for this heavy metal. Another challenge is to promote a traceability system for the cocoa value chain, which is an essential requirement for competing in international markets. In addition, continuing the development and transfer of new varieties, training and promoting good agricultural practices, especially regarding post-harvest and addressing the financial difficulties faced by small growers in gaining access to certifications are additional challenges. As for the local market, it is necessary to improve the warning system for labels on cocoa products, as it does not distinguish healthy cocoa fats from other risky fats and adds them together without any discrimination, resulting in products that warn of their high fat content, ultimately discouraging their consumption. Among the main challenges facing the cocoa sector in Venezuela are the need to increase production, within the framework of sustainable and inclusive productive development, the consolidation of a constant and good quality exportable supply, and the creation of an institutional framework with characteristics that promote

development and increase investment in the sector. In fact, a primary challenge is to promote production, strengthened by an institutional framework for the development of sustainable enterprises, and its incorporation into formal value chains, both at the local and global levels. Other important challenges are to mitigate the risks of cocoa in the forests due to the environmental externalities it causes, improve the poor health and safety standards of cocoa production, minimize social conflicts related to land use rights, and improve farmers' wages and livelihoods.

As far as pitahaya (dragon fruit) in Ecuador is concerned, the main challenges include low productivity due to the lack of technology to achieve higher yields and control pests; and low investment in research to develop new varieties, since those that are exported are local native varieties. Given that good practices promoted by the integration of the industry have remained limited to a small niche, the inappropriate use of pesticides and fertilizers predominates in much of the production. Another important challenge is that related to financing: only 4% of growers finance their activity through formal credit, and uncertainty about their income, due to international price volatility in recent years, is a risk factor for their business. In addition, pitahaya requires about four years of growth before production begins, so access to credit may be a critical consideration for starting production. Other challenges include improving the efficiency of national certification for best agricultural practices and organic and environmental certifications so that local growers can reduce the high cost of international certifications. As a result of the numerous challenges facing the sector, many of these competitive advantages of Ecuador's pitahaya have not been fully harnessed.

Barriers limiting the development of blackberry in Ecuador and access to international markets include the lack of associativity among producers, resulting in greater market power by intermediaries, who buy 85% of the production directly at the farms; low quality standards, without Best Agricultural Practices and organic production certifications, and the lack of a traceability system. Likewise, the low implementation of newly developed crop technologies[16] by the National Institute of Agricultural and Livestock Research (INIAP) results in high production costs and low productivity levels. Estimates[17] indicate that INIAP's technology could reduce these costs to $0.49/kg from the conventional cost of $0.63/kg. The challenge persists to enhance and allocate more resources to disseminate these technologies and other innovations, as well as to develop other disease-resistant varieties, and to promote the endorsement of their "credential attributes," particularly the use of quality certifications, organic production, and environmentally safe production processes.

Among challenges facing the blueberry sector in Peru to continue growing are the provision of basic public services, especially pest control and phytosanitary investment, to prevent each individual company from having to solve common problems. Variety innovation will require attracting investment and greater access to financing. Peru does not have an operational first-tier development bank for medium- or large-scale agriculture and, in general, medium- and/or long-term financing for the agricultural sector is limited.

Challenges in the tuna sector in Venezuela include adjustments in the regulatory and legal framework to achieve proper incentives for the industry's restoration. Also, redirecting exports to other markets in Europe and Asia, obtaining environmental certification to maintain competitiveness amid new international requirements, and fully adapting the industry to remain competitive after the elimination of its subsidies.

16. These are cultivation and harvest guidelines that encompass integrated pest management, fertilization, soil management, water management, improved genetic material, among others.

17. Estimates correspond to Barrera *et al.* (2017) and Galarza *et al.* (2016).

As for Venezuela´s coffee industry, it faces several challenges such as achieving an increase in production, environmental sustainability and greater productivity by its growers. Similarly, having a greater integration between the links in the value chain that will allow the entire production process to benefit from the generation of greater added value is another of the challenges. There are also the issues related to the lack of institutional support for the sector to promote greater dynamism and formal industrial integration, attract investments required by the sector and, finally, generate greater resilience to climate change and rust, while protecting the environment and benefiting populations linked to its production that are more vulnerable to climate change.

To become more competitive, Venezuela's shrimp industry faces the challenge of rapidly increasing its production acreage with new farming technologies that require large investments in the country's challenging economic context. Small and medium-sized exporters also face the challenge of reduced access to financing to purchase inputs and increase the production base, as well as to invest in farming technology, making it impossible to compete with large companies that dominate the sector. The possibility of future growth of this industry will thus depend on the capacity for constant interaction between shrimp companies and input supply industries, and on the government's ability to support the supply of ideally clean-generated energy, as well as good phytosanitary regulations. Another challenge facing this industry is to advance in its environmental sustainability and in obtaining environmental certifications that will allow it to benefit from better prices.

6.4 Potential opportunities for Andean superfoods

Courtesy IDB/Patricia Rincón

This section focuses on opportunities to promote superfoods in the Andean region in a sustainable and inclusive manner, with a positive socioeconomic impact on the different components of the production chain. As in the preceding section, an alphabetical order by country is followed. Although each superfood has specific opportunities based on its inherent characteristics, it is also true that there are common development possibilities for this niche.

First, there is the constantly expanding international demand for foods with intrinsic nutritional and healthy properties that imply sustainable and environmentally friendly consumption, but which also have a positive impact on the livelihoods of growers. A second common area of opportunity for this niche is the development of a product brand focused on quality and product differentiation through green or environmental certifications and/or designation of origin that will enable conquering new markets and consolidating those that have already been accessed.

These superfoods also have the potential to develop a national superfood industry and market that offers added value to consumers, together with the development of production models with good environmental practices, high productivity, and innovation and diversity of supply. In the case of most superfoods, it is even possible to enter new industries beyond the food industry, such as pharmaceuticals, agricultural tourism, cosmetics, and nutraceuticals just to mention the most important ones.

In the particular case of each superfood considered in this chapter, starting with Bolivia, the superfood designation has kept Amazon nuts with a constantly expanding global demand and price. The opportunities in this sector go beyond its nutritional qualities, since its ecological component is also attractive as it is an activity that allows for the conservation of the Amazon forest. It also has a positive socioeconomic impact by generating employment and income in the region, which allows the product to be characterized with a mark of sustainability in socio-biodiversity. In terms of industrialization and marketing of value-added products, Amazon nuts have a high potential within a wide array of industries ranging from confectionery and the production of almond milk[18] to cosmetics and personal care products.

The topography of the plains characteristic of the Bolivian Chaco producing region is undoubtedly a competitive advantage that has facilitated the mechanization of peanut cultivation with higher yields (1,700 kg/ha) than in other regions (1,300 kg/ha). As part of the Andean Community of Nations (CAN), Bolivia benefits from tariff preferences that make Ecuador and Colombia its most promising destination markets for expanding exports. At the same time, considering the growing international demand for organic peanuts, especially in Europe, the country also has the opportunity to continue expanding organic peanut cultivation for marketing in other countries.

18. Highlighted is the potential of Amazon nuts as a raw material for the production of almond milk, substituting cow, soy or oat milks.

Growing global demand for healthy and nutritious foods and the revaluation of quinoa in international markets represent the main opportunity to boost its value chain in both Bolivia and Peru. This is of particular benefit to the indigenous peoples and women, especially for Bolivian Quinoa Real, which already has a designation of origin that recognizes its quality differentiation at the national level and by the CAN. In fact, obtaining such recognition in other latitudes (Europe, USA and Asia) would improve its valuation (price) and access, in addition to its already earned fame for being the most demanded and appreciated in the international market.

Potential opportunities for strengthening the sesame agroindustry in Bolivia include the fact that the high quality of the exported product is the key factor in reaching other potential markets such as the United States, Korea and Taiwan, and China. Furthermore, the development of the black sesame variety is seen as a potential product for niche markets, where Bolivia could also specialize in specific varieties for oil production. Another opportunity is to accelerate the production of organic sesame, which is highly demanded in the world, for which state support would be needed for financing and genetic research.

The avocado industry continues to expand, making demand for avocados the main source of opportunities. The Andean avocado has the potential to currently generate the benefits derived from the coffee industry, as occurred in Colombia in the twentieth century. It has a positive impact on infrastructure connections to international ports and the development of a country brand focused on quality and environmental sustainability. Moreover, the potential of avocados is not limited to fresh exports. Avocado derivatives, mainly oil, represent an important complementary market that takes advantage of agricultural production waste and improves income for growers.

Opportunities for cocoa in Ecuador stem from the increase in global demand for chocolate estimated at USD 41.15 billion for the five-year period 2020-2024. Noteworthy are the non-traditional markets for chocolate consumption, such as Asia, and the emerging niche markets that show a high appreciation for cocoa quality and differentiation. Ecuador has a wealth of varieties, as well as ideal agro-ecological conditions for the optimal growth and development of cocoa, especially in the coastal provinces. Two powerful mechanisms to enhance these opportunities lie in the implementation of production traceability systems and the achievement of multidimensional credibility attributes.[19] Finally, there is a window of opportunity to develop a domestic industry that adds value to cocoa, since currently only 1% of Ecuador's total cocoa production is processed into chocolate by local firms, and 9% is destined for semi-processed products for domestic consumption and export. By taking advantage of the broad cocoa value chain and particularly the strength of Venezuelan cocoa, which is based on its quality and diversification, there is a potential opportunity to promote sustainable development models that encourage inclusive trade and reduce poverty by implementing good agroforestry production practices, financial support and technical assistance in quality, variety and value-added generation.

Some of the key aspects include access to financing for greater capital accumulation and learning to increase the sector's productivity, and innovation to diversify cocoa supply in the food, cosmetics, phytopharmaceutical and even agricultural tourism industries, through roadmaps that enable the enrichment of products with sustainable brands and market consolidation along the entire value chain "from the farm to the table".

Expanding demand from the United States, European Union countries and Asia, coupled with increasingly favorable prices, offer a significant opportunity for growth in Ecuador's pitahaya (dragon fruit) sector. The benchmark price maintained an increasing trend, averaging USD 5,874 per ton in 2019, more

19. These include designation of origin, organic production, fair trade, environmentally sustainable production processes, and healthy and artisanal chocolate products.

Francisco Espinoza.

than six times the 2005 value. Given that the characteristics that differentiate the quality of Ecuadorian pitahaya make it possible to obtain attractive prices, a room for growth for this sector is to customize products according to the specific demands of destination markets and meet standards imposed by modern shoppers. The growing world demand in particular opens a window of opportunity for product differentiation through certifications that allow penetration into new attractive markets such as that of organic fruits.

With regard to blackberries in Ecuador, a market opportunity would be to boost exports of fresh and processed blackberries, following the successful experience of neighboring countries. The main window of opportunity currently arises in the U.S. market, where imports have grown 36% between 2017 and 2020. It should be noted that Ecuador has a production period with low prices between September and February, which coincides with the period of zero production in the U.S. Another advantage is that Ecuadorian production has lower production costs of 0.63 USD/kg, versus 3.00 to 3.75 USD/kg in the U.S.[20] It should also be noted that Ecuador has already been exporting to that market since 2015, but in small quantities; however, there are favorable conditions to increase these sales, given that in 2017, both countries signed an operational work plan that establishes phytosanitary measures and certifications to comply with the regulations of that market.

20. Despite this, exporters indicate that in order to compete in this market, production costs need to be less than 0.55 USD/kg.

Blueberries in Peru show important opportunities, including their potential for processing and incorporating added value, which makes this product attractive, for example, due to its use in the nutraceutical industry and the use of "discards" (product that did not meet the standards to qualify as fresh), since it maintains a high quality and is an input for processed products.

The tuna industry in Venezuela is currently facing new conditions, with great potential due to the new domestic context with no price controls. In the case of tuna fishing even far from the Venezuelan border, the opportunities for the tuna sector are centered on its processing capacity and experience in the sector, which, added together, could boost the product's export potential.

The growth in global coffee demand of 2% per year worldwide will require that by the year 2050 world production triples. Most of this demand comes from markets that promote sustainable consumption, valuing environmentally friendly processes. An opportunity for Venezuelan coffee in the face of this growing world demand could be exploited through the renovation program of coffee plantations with rust resistant varieties. Another opportunity in which the country could participate would be to differentiate itself as a brand by means of green seals and certifications. To this end, adequate promotion is required for the payment of environmental services as an incentive for coffee forest conservation.

Given its natural advantages, such as the large extensions of flat coastal lands near waters with high organic components, its high temperature and the productivity of the sector, shrimp in Venezuela enjoys all the conditions to increase its export volumes, surpassing its main regional competitors, such as Ecuador. Another potential opportunity for the shrimp sector would be to achieve product differentiation in terms of quality and environmental certifications in order to break into the European, Asian, and North American markets. An additional potential opportunity for the shrimp sector would be greater vertical integration with Venezuelan companies in the agroindustrial sector, with a view to supplying themselves with food inputs.

To close this chapter, some successful lessons can be extracted from some superfoods that can be applied to others. For example, commitment to quality has been crucial for the success and positioning of Ecuadorian pitahaya and Bolivian sesame in export markets, and has been the key factor in positioning them in export markets and obtaining attractive prices. The ecological component in favor of forest conservation with a mark of sustainability and socio-biodiversity is a hallmark of success for Amazon nuts in Bolivia. Certifications recognizing the differentiation and quality of Bolivian Royal Quinoa, which also has a designation of origin, have played a decisive role in boosting demand for this superfood, as well as its price in export markets. Another lesson that can be replicated in other cases of superfoods is diversifying the supply with derivatives, as with avocado and its oil, as well as the use of waste, as in the case of blueberries as an input for processed products. Lastly, the case of Ecuador's cocoa stands out: its differentiation based on a production traceability system and multidimensional credibility features such as designation of origin, agricultural production, fair trade and environmentally sustainable production were key to its success worldwide.

7

FORESTRY

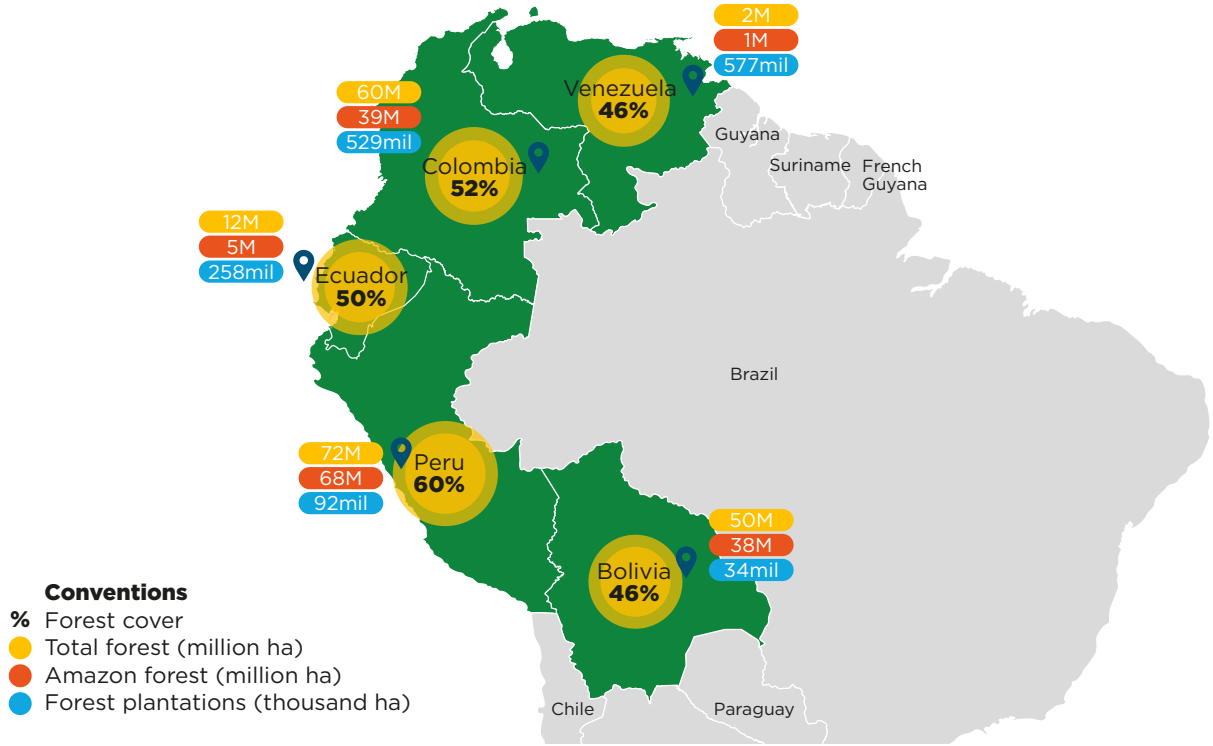
7. AN UNDER-EXPLOITED POTENTIAL: THE FORESTRY SECTOR IN THE ANDEAN- AMAZONIAN COUNTRIES

7.1 Introduction

Between 40% and 60% of the territory and forests of the Andean countries are within the great Amazon basin, which is rich in flora and fauna diversity and probably, as a whole, contains the richest forests on the planet. This natural wealth translates into a high potential for the sustainable management of natural forests and the establishment of forest plantations, activities that would also improve the livelihoods of local populations.

The Andean-Amazon countries[1] cover a territory of almost 4.7 million square kilometers (km^2) with approximately 2.4 million km^2 of forest and forest plantations by 2020; half (51%) of this regional territory corresponds to native forest and forest plantations. Sixty-five percent of the forest canopy is Amazonian forest.

Figure 7.1 Total area (hectares) of forests and plantations, Amazonian forest, plantations, and within indigenous territories in the Andean-Amazonian countries



Source: Prepared by the authors with data from national statistical institutes and the Ministries of Environment and Economy of the different countries.

1. Bolivia, Colombia, Ecuador, Peru and Venezuela.

- More than 60% of the **Peruvian** territory is covered by forests (72 million hectares). It is one of the countries with the highest forest cover in the world, and the second after Brazil with the highest coverage area of Amazonian forest (68 million hectares). Three Amazonian departments account for 77% of the total forest area: Loreto with 51%, Ucayali with 14% and Madre de Dios with 12% (FAO, 2020a). The country maintains concessions over an area of 15 million hectares (ha), or 21% of the forest. There are 9 million hectares in place, of which 0.9 million hectares are certified with ten companies with FSC[2] good forest management practices (FSC, 2021).

- **Colombia** has 58.5 million hectares of forest, only 9.5% of which have been defined as suitable for management, and of these, 4.4% are under forest management. Logging contributes 0.4% of the gross domestic product (GDP), and the costs of operating legally represent up to 25% of extraction; the use of illegal timber accounts for up to 50% of consumption. According to the Ministry of Agriculture, 450 million hectares of plantations are available.

- The contribution of the forestry sector to **Bolivia's** GDP has been close to 3% since 1997. Although the Amazon region represents more than 38% of the country's territory, it makes a marginal contribution to the country's economy; 1% of Amazonian territory under forests generates 0.009 of GDP, while 1% in the rest of the country generates 1.6%, i.e. 8,000 times more.

- According to the Ministry of Environment, Water and Ecological Transition, there are 12,631,198 hectares of native forests (MAE, 2018) in **Ecuador**. Of these, 74% are located in the Amazon, 15% in the coast and the remaining 11% in the Ecuadorian highlands (MAE, 2018). Indigenous communities own between 5 and 7.5 million hectares, and are key actors for managing and conserving forest resources (Añazco *et al.*, 2010; Palacios and Freire, 2004). However, due to anthropogenic pressures, Ecuador's forests have experienced a loss of forest cover in recent decades. The main causes have been land-use change for agriculture and pastures, the opening of roads, population growth and timber extraction followed by land-use change (Sierra *et al.*, 2021; Torres *et al.*, 2020; Mena *et al.*, 2006; Hosonuma *et al.*, 2012; Sierra, 2013; Wasserstrom and Southgate, 2013).

- **Venezuela** has an area of 916,445 km^2 with a forest cover of 46,230,900 million hectares. The largest area of forest (83%) is located in the states of the Guayana region: Bolivar (39%), Amazonas (37%) and Delta Amacuro (7%), most of which (47%) is within the system of Areas Under Special Administration Regime (ABRAE). The Amazon region of Venezuela, with more than 50% of the territory, is located mainly in the south of the country in the extension of the Orinoco River (FAO, 2020b).

2. Forest Stewardship Council (FSC).

The five Andean-Amazon countries account for around 59 million hectares (25% of the territory) in Protected Areas (PAs),[3] where land tenure is mainly state-owned, in some cases also under joint administration, and where the harvesting of timber and non-timber forest products (NTFPs) is not usually permitted. In these PAs, state presence in general is null or minimal (in terms of control and production), and local subsistence production takes place.

Indigenous communities with communal lands, as well as settler/mestizo farmers[4] and from diverse peoples and nationalities, play an important role in the use, management and conservation of the remaining native forest resources. Most of these lands are in Colombia and Peru, followed by Ecuador and Bolivia with similar areas, and lastly, Venezuela. While the government allows logging and the harvesting of timber and non-timber products in the territories of indigenous and other communities (farmers, settlers/mestizos, and diverse peoples and nationalities), this production is normally on at a low scale or subsistence level.

The Andean-Amazon countries have a high potential for the sustainable management of natural forests and the establishment of forest plantations.

- In **Colombia**, land tenure with forest cover totals 26 million hectares (43% of the country) and is in indigenous peoples' communities (MADS, 2022).
- In the **Peruvian Amazon**, 16 million hectares represent 22% of indigenous and communal land (CNF, 2022).
- In **Ecuador**, between 5 and 7 million hectares are under community titling by indigenous peoples and nationalities, equivalent to 40%-60% of the country's forests (MAE, 2018).
- Origin community land in **Bolivia** represents 7 million hectares (INRA, 2020).
- In **Venezuela**, local, tribal and indigenous community ownership is almost 1 million hectares (FAO, 2020b).

3. The definition varies across the five countries in the study, but in general they are defined geographic spaces, officially declared and designated with a management category by virtue of their natural, cultural and/or socioeconomic importance, to meet certain conservation or direct use objectives, in which, through management plans, the traditional use and sustainable exploitation of natural resources by local populations is allowed.
4. Category given to the people who colonized the Ecuadorian Amazon Region (RAE), mainly since the 1960s, taking advantage of the Agrarian Reform and Colonization Law enacted in 1964.

Table 7.1 Category of forest use and land tenure (hectares) in Andean-Amazon countries

Country	Venezuela		Colombia		Ecuador		Peru		Bolivia		Total	
Category	**Ha**	**%**	**Ha**	**%**	**Ha**	**%**	**Ha**	**%**	**Ha**	**%**	**Ha**	**%**
Protected areas	3,473,712	7%	9,200,000	15%	6,168,350	51%	22,440,000	31%	17,696,065	35%	58,978,127	25%
Tribal and indigenous lands	939,000	2%	25,900,000	43%	5,000,000	41%	15,640,000	22%	7,198,824	14%	54,677,824	23%
Afro-descendant communities		0%	3,300,000	6%		0%		0%		0%	3,300,000	1%
*State-owned land with allocation restrictions	35,383,571	76%	6,500,000	11%		0%	6,120,000	9%	153,609	0%	48,157,180	20%
Forest in private or community areas, and forest plantations	144,310	0%	13,400,000	22%	913,216	8%	10,300,000	14%	4,043,412	8%	28,800,938	12%
Forestry concessions		0%		0%		0%	7,400,000	10%	13,183,074	26%	20,583,074	9%
Forest and peasant reserves	6,742,407	14%	1,300,000	2%		0%	10,000,000	14%	7,586,995	15%	25,629,402	11%
Totals	46,683,000	19%	59,600,000	25%	12,081,566	5%	71,900,000	30%	49,861,979	21%	240,126,545	100%

Source: own elaboration with data from DANE (2022a); CNF (2022); IDEAM (2022); INRA (2020); FAOSTAT (2022); MAATE (2022), MAG (2020); MINAMBIENTE (2022); MINEC (2021); MMAyA-OTCA (2015) and Morales (2013).

Note: *The State assigns property rights to a public sector authority. In some countries, forest lands may be under state mandate, either the central power or a decentralized government.[5]

For the region's productive natural forests, the number of commercial species is small in relation to the potential of these ecosystems.

- In the case of **Peru**, half of timber forest production (PFM) is concentrated in six groups of forest species, mostly hardwoods for flooring (deck) (SERFOR, 2010-2021):

  - Shihuahuaco or cumaru or tonka bean (6 species of the genus *Dipteryx sp.*).
  - Tornillo or screwbean cedar (1 species *Cedrelinga catenaeformis*).
  - Cachimbo (6 species of the genus *Cariniana sp.*).
  - Capinuri or crabwood (*Maquira coriacea [Karsten]*).
  - Copaiba (*Copaifera paupera [Herz.]*).
  - Cumala (5 species of the genus *Virola sp.*).
  - The rest was represented by a hundred of other forest species.

5. Definitions of land tenure are available at https://www.fao.org/3/y4307s/y4307s05.htm.

- In the case of **Bolivia**, during the period 2015-2020, twenty species were reported, headed by ochoo or sandbox tree (*Hura crepitans*), bibosi or fig (*Ficus sp.*), Serebo (*Schizolobium parahyba*), tajibo or pink trumpet tree (*Tabebuia impetiginosa*) , among other species.

- Regarding **Colombia**, there are fine woods such as: cedar (*Cedrela sp.*), ceiba tolúa (*Pachira quinata*); timber species for structural use such as: chanul (*Humiriastrum procerum*), abarco (*Cariniana pyriformis*), oak or purple flower (*Tabebuia sp.*); fine carpentry: purple flower (*Tabebuia rosea*), coffee walnut (*Cordia alliodora*), cedar (*Cedrela sp.*), moncoro (*Cordia sp.*), cumin (*Aniba sp.*). ceiba tolúa (*Pachira quinata*) and guayacán (*Tabebuia sp.*) (MINAMBIENTE and ONF Andina, 2018).

- **Venezuela** has forest species such as samán or rain tree (*Albizia samán*) and mureillo (*Erisma uncinatum*) (OTCA, 2019).

Non-timber forest products (NTFPs) of high economic importance and strategic relevance for food security and rural community development have been utilized since ancient times as medicinal, food and ornamental plants. Populations living in and near the forest have an intense use of NTFPs to improve their livelihoods. A consolidated example of this is the Amazon nut, which in 2022 made Bolivia the world's leading exporter of this fruit. Other examples of non-timber forest products include:

- Tagua or vegetable ivory palm (*Phytelephas aequatorialis*), the seeds of which are used to make buttons and other crafts.

- Quinine (*Cinchona officinalis*), historically used to treat malaria, and matico de monte (*Piper aduncum*), a medicinal plant with anti-inflammatory and wound-healing properties.

- Chonta or peach palm (*Bactris gasipaes*) whose fruits are an important food source for Amazonian indigenous populations.

- Guadua or bamboo (*Guadua angustifolia*) used for structural construction, furniture, decorative and kitchen items, and even for culinary purposes.

Table 7.2 Main non-timber forest products (NTFPs) for Andean-Amazon countries

Common name	Scientific name	Main use
Venezuela		
Amazon nut and cream nut	*Bertholletia excelsa*	Food
Peach palm or guili	*Bactris gasipaes*	
Cupuacu	*Theobroma grandiflorum*	
Assai palm or açaí Palm	*Eutherpe precatoria y Euterpe oleraceae*	
Sarrapia or tonka bean	*Dypteryx odorata y Dypteryx punctata*	Food and cosmetics
Rubber tree	*Hevea brasiliensis*	Industry
Piassaba palm	*Leopoldinia piassaba*	Construction
Colombia		
Arazá or Amazonian pear	*Eugenia stipitata Mc Vaught*	Food
Cacay nut tree	*Caryodendron orinocense Karsten*	Food and cosmetics
Coca plant	*Erythroxylum coca*	Medicine
Arrow cane	*Gynerium sagittatum*	Industry and handicrafts
Guadua or bamboo	*Guadua angustifolia*	Construction
Ecuador		
Vanilla	*Vanilla spp.*	Food
White cacao	*Theobroma bicolor*	
Aguaje or burahem	*Mauritia flexuosa*	
Peach palm or guili	*Bactris gasipaes*	
Bataua palm	*Oenocarpus bataua*	Food and cosmetics
Dragon´s blood	*Croton lechieri*	Medicine
Guayusa	*Ilex guayusa*	Medicine and food
Andean cinnamon or ishpingo	*Ocotea quixos*	Medicine and cosmetics
Peru		
Amazon nut and cream nut	*Bertholletia excelsa*	Food
Cat´s claw	*Uncaria spp.*	Medicine
Aguaje or burahem	*Mauritia flexuosa*	Medicine and food
Copaiba	*Copaifera paupera (Herz.) Dwyer*	Medicine and cosmetics
Rubber tree	*Hevea brasiliensis*	Industry
Bolivia		
Amazon nut and cream nut	*Bertholletia excelsa,*	Food
Assai palm or açaí Palm	*Eutherpe precatoria y Euterpe oleraceae*	
Bataua palm	*Oenocarpus bataua*	
Cupuacu	*Theobroma grandiflorum*	
Rubber tree	*Hevea brasiliensis*	Industry

Source: Own elaboration based on reports and consultations in the countries.

While forests are the main land use in all the Andean-Amazon countries, this is not prominently reflected in their economies (GDP, exports, per capita wood consumption, percentage of wood in urban construction, etc.), in the social sector (rural employment, services and industry) or in the environmental sector (carbon balance, biodiversity, water production, landscape beauty, etc.), indicating untapped potential and passively oriented conservation. In general, production, export and import figures are low and clearly show that the forestry sector is marginal within the economy of each of the countries. Forestry is far from achieving what it could really contribute to the national economy, ecosystem management and improvement of people's livelihoods.

In terms of generating economic opportunities for the population, it has been estimated that between 350 and 375,000 direct forestry jobs have been created in the Andean-Amazon region. This figure is modest compared to employment in the agricultural sector.[6]6 Furthermore, the sector is still characterized by the scarce presence of women in the value chain and their low participation in decision making in logging operations, factories, companies and forestry businesses.

- **Colombia** has 75 thousand direct jobs and 280 thousand indirect jobs, the smallest contribution is forestry (ONF Andina, 2018).

- **Bolivia** has 90 thousand direct jobs and 210 thousand indirect jobs (CFB, 2022).

- **Perú** generates between 83 and 100 thousand formal direct jobs and 800 thousand informal jobs estimated for the entire value chain (CoV); secondary processing (furniture manufacturing) accounts for the critical mass of workers (FAO & ITP/CITE Madera, 2018).

- **Ecuador** indicates that among formal companies that declared their balance sheets to the Superintendence of Companies, they generated a total of 2,034 jobs, which corresponds to eight employees per company. The private forestry sector union (AIMA, 2020) reports around 300,000 direct and indirect jobs.

- **Venezuela** does not report official figures. Inquiries made to manufacturers report between 2,700 and 7,300 direct jobs and 13,400 indirect jobs.

6. For example, four million agricultural workers in Peru and 2.2 million in Ecuador.

7.2 Challenges that prevent forestry from being a winning sector for Andean economies

The potential of forestry in the Andean-Amazon countries has been limited by various factors, including regulations, informality, and more broadly, the prevailing preservation of forest resources.

Despite the high potential of forestry, in most countries, forest management has been discouraged and preservation of the resource has prevailed, resulting in little or no investment and job creation. In part, the sector has faced a major challenge in explaining to the authorities and the population how good forest management is effective in conserving both tropical and Andean forests.

In addition to the reputational and communication issues, logging, especially in native forests, continues to be an almost invisible activity. There is a large amount of informal logging that is not registered and, consequently, is not counted as an activity that generates employment or contributes to domestic revenue for the countries. There is a high level of informality throughout the forestry value chain (50% to 80%, depending on the link in the chain and the country):

- Employment generated in forestry harvesting generally takes place in rural areas, with high rates of informal labor.
- Most employment is in the secondary processing industry,[7] which is also highly informal due to its atomization and generally located in urban centers.

Similarly, illegality in timber forestry is present in the different links of the production chain, from harvesting in the forest to marketing the final product, according to data from Alianza Fauna y Bosques (2022):

- In **Ecuador**, 21% of the establishments that process timber are illegal; that is, they operate without a permit and have no transport guide generated to them.
- In **Colombia**, the Ministry of Environment estimates that 47% of all timber sold in the country is illegal.
- In **Peru**, illegal logging ranges between 40% and 50% of production and generates large economic losses.
- In **Bolivia**, 50% of the timber is illegal. Bolivia ranks 4th in the world and 2nd in Latin America in terms of primary forest loss.

7. The secondary forestry industry in Peru includes the following: (i) sawmills that make semi-finished products (profiled wood for interior and exterior flooring, moldings, molded boards, spools (cable drums), pallets, laminated wood and assembled boards for flooring; (ii) plants producing laminates and boards, packaging and pallets, and other semi-finished products (tableware, kitchenware, and wooden handicrafts); and (iii) plants producing furniture, doors, and wooden furniture parts (PCM *et al.* , 2021a).

Almost all Andean-Amazonian countries have had agrarian reform processes since the 1960s. However, these have not been fully completed. There is no territorial ordering or clarity in land ownership among the State, indigenous and peasant communities, and private owners, which leads to conflicts between groups and hampers the interest in investing in sustainable forest management of natural forests and plantations on the scale that the magnitude of the resource would allow. Indigenous lands have been generally allocated, which does not mean that they have been put under forest management, but rather that they have changed their use to subsistence agriculture. Land tenure by migrants and settlers has been largely spontaneous as well as disorganized, creating conflicts over ownership. There are also a large number of areas declared as protected, in which the State has very little capacity, both in terms of budget and personnel, to actually protect them. There are many invasions in these areas.

On the other hand, despite the undeniable importance of infrastructure to facilitate rural development and increase the effectiveness of value chains, there is a need for clear planning and management of these territories so that these access roads do not respond to private profit-making interests without taking into account the environmental, cultural and social sensitivities of these territories. Currently, more than twenty projects for the construction of giant highways are pressuring the Amazon, which could lead to a rapid increase in forest loss.

Poor development of the sector is also largely due to the obsolete institutional and legal framework, based on command and control rather than on the promotion and encouragement of investment. There is a widespread perception in the countries under study that legal regulations require compliance with requirements and conditions that are considered excessive and expensive, which leads to reactions against their application and stimulates informal and illegal logging, processing and marketing of timber and non-timber products.

On the other hand, transaction costs are high, associated with regulations, legal certainty, lack of market information, taxes, transportation, patents, certifications, among others. Such costs can take the form of excessive red tape, a multitude of public organizations and weak institutional frameworks, or when public officials interpret processes in a discretionary manner (PCM *et al.*, 2021a). In many cases, these transaction costs of timber production in the forest put legal operators out of business. Forestry has transaction costs that sectors such as agriculture and livestock do not have. For example, in some countries, prior to harvesting, it is necessary to obtain approval of a permit to cut the trees: a forestry cutting permit for on-farm trees, a cutting plan for forest plantations or a management plan for forests or similar. Thus, there is strong asymmetry in the way the land-using sectors are treated and this makes forestry less competitive (Louman, 2002):

- Land tenure uncertainty in forest areas.
- Increased profitability in crops such as soybeans, oil palm, livestock, tropical fruits, without considering their environmental and social costs.
- A low proportion of income generated remains with the farmer and logging worker.
- Cash flow from forestry is unfavorable compared to other annual or short-cycle crops.
- Excessive, cumbersome, slow and often restrictive legal procedures with no scientific, technical or economic basis.

- High taxes, often prior to receiving income.
- Higher susceptibility to influence peddling.

Land use change from forests to agriculture, livestock and mining are some of the pressures that put forestry at risk. These activities, which are associated with degradation, deforestation and forest fires, threaten the integrity of ecosystems, species, communities and the wide variety of goods and services they provide. Some 92.2 million hectares, or 38% of the Andean-Amazon forests, are classified as productive, and this potential is increasingly underutilized.

Deforestation is a constant challenge for the sector. Between 2000 and 2013, the Amazon lost 5% of its forests, from 575 million hectares to 548 million hectares. The expansion of pastures and crops, which increased by approximately 23 million hectares in the same period, is the main cause of deforestation in the region. Bolivia has the highest rates of forest loss in the Andean-Amazon region, as, in 2017, the gross rate of change (deforestation)[8] was -0.49%, i.e., a loss of forest of 263,000 ha/year. If policies and strategies are not advanced to reduce deforestation in the Amazon biome, the Amazon may lose 27% of its forests (about 85 million ha of forests) by 2030.

Forest fires represent a cause of degradation of forest ecosystems in the region, with Bolivia standing out with 3.6% of the area affected in 2020. The rest of the countries report less significant area affected between 2017 and 2020. The main causes include intensive agricultural and livestock activities that change the use of forest land, as well as natural phenomena.

The Andean countries are lagging behind in technology and processing along the entire forest chain, mainly in adding value to natural tropical forest timber: old and obsolete machinery in forest harvesting, both primary and secondary processing of timber, idle installed capacity due to administrative processes and conditions imposed by markets, limited innovation and use of state-of-the-art technology, poor use of available tools and platforms for market access, and low public awareness, among other factors.

As a result, forestry entrepreneurs have not been able to obtain legal security over the forest areas they operate, which prevents long-term investment in the sector thus limiting their ability to offer new products and designs. The presence of intermediaries is another challenge for timber producers; in particular, transportation to the processing plant, which is one of the most significant costs (the second most important after harvesting costs and the closing of forestry activities) and has become a limiting factor. Income generated by the commercial activity is not distributed fairly along the entire chain. Most of the financial benefits are captured by intermediaries, affecting mainly private forest landowners, mostly in rural areas and with significantly lower human development indices than in more densely populated regions, such as urban areas. In addition, there is a lack of appropriate incentives for further investment. Entrepreneurs face a lack of technical assistance for scaling up, the need for cash flow support, and the lack of continuity of initiatives in the face of political changes, etc.

Finally, availability, access, updating and statistics on forest resources in each of the countries, such as harvesting, marketing and employment, represent another major challenge facing the region as a whole. In general, records are inaccurate, isolated and outdated, which hinders adequate decision making by all actors involved in the forest sector value chain.

8. A gross deforestation rate means loss of forest vegetation due to induced or natural causes.

7.3 Opportunities for setting new foundations for the forestry sector in the Andean region

One of the best conservation methods is through good forest management. Managed forests remove more carbon than unmanaged forests. Managed natural forests grow and sequester carbon; in addition, long-life wood products (houses, buildings, bridges, furniture, musical instruments) maintain and permanently increase carbon storage.

There is great potential for both forest and plantation management, as well as TFP and NTFP production in the region. All Andean-Amazon countries, without exception, have proportionally large areas of tropical forests, as well as areas with potential for reforestation. This leads to the possibility of producing large volumes of TFPs from native species as well as from plantations and, in addition, sustainably harvesting the NTFPs that these areas contain. The production of timber from plantations and natural forests does not compete with NTFPs, but complements and challenges innovation and the development of new products.

Managing forest concessions well is possible. In all countries studied, there is a vast area with suitable conditions for establishing and managing forest plantations with species that have already proven to be adaptable, show rapid growth due to the selection of genetic material and are suitable for industrialization and marketing. It is estimated that the Andean-Amazon region has a potential for the development of forest plantations of more than 55 to 60 million hectares (of these, more than half, i.e., 25 million hectares, in the Amazon departments), distributed as follows:

i. **Colombia** has a forestry potential of 24 million hectares for commercial production according to the Map of Zoning for Forest Plantations for Commercial Purposes (data from the Rural Land Planning, Land Adequacy and Agricultural Uses Unit), but of these only 1.6 million hectares are located in five Amazonian departments.

ii. **Bolivia** has 11.1 million hectares, all in the Amazon (Bascopé, 2022).

iii. **Venezuela** reports that it has a potential of up to 9.3 million hectares (almost 2 million in the Amazonian state of Bolivar), an area that has been identified since 1991, according to Decree 1660 for reforestation.

iv. **Perú** has 8.5 million hectares of underutilized or abandoned Amazonian forests on which forest plantations could be developed (CNF, 2022).

v. **Ecuador** counts with 4.5 million hectares, of which 1.1 million hectares are in the six Amazonian provinces. However, it is worth noting that the prioritized activity is for restoration, while the establishment of forest plantations and agroforestry systems for commercial purposes are considered secondary activities (MAE, 2019).

In all countries, there are FSC-certified forests, especially in the form of forest plantations, but there are also tropical natural forests, and both have existed for many years. This is an experience that can be scaled up if better conditions for Sustainable Forest Management (SFM) are provided. In addition, markets and certification itself are more sensitive to the characteristics of structure and composition of the tropical

forest. There are no major problems with forest plantations, since silvicultural management is simpler, markets are safer and certification costs are lower.

Continuing to promote the various timber and non-timber value chains in all the countries of the Andean region is crucial for developing the forestry sector and generating income opportunities for vulnerable populations living in forested areas (see Boxes 7.1 and 7.2). Nevertheless, it is essential to continue identifying more products and ways of adding value to position

forest products as "niche products". Countries have the opportunity to develop new forest products and open markets, taking advantage of new trends. One of the main principles of this strategy is the design of new wood products, as well as the efficient substitution of wood substitutes (steel, aluminum, concrete, plastic). In other words, what used to be made of wood, and has been replaced by products with a high environmental footprint, should be manufactured again with wood, but with high quality and innovative designs.

Continuing to promote both timber and non-timber value chains is crucial for the development of the forestry sector and for income generating opportunities for the population.

Considering the importance of the furniture industry in each country, it is recommended that a medium- and long-term plan be developed for the design, innovation, improvement and integration of wood furniture and furnishings production. Creating a market strategy that replaces everything that is not made of wood is suggested. A suitable use will also have to be sought for species that are currently less commercial.

A special plan for the incorporation of wood in the construction of social housing and service infrastructure, such as health clinics, schools, public service centers, recreation centers, among others, is suggested. Obviously, this plan should be carried out in stages to gradually replace high-carbon footprint materials with wood, especially from the tropical forest and lesser-known woods. This may represent high volumes of wood consumption. A practical application would focus on addressing housing deficits.

Box 7.1. Boosting timber and non-timber value chains

Timber products

- **Bolivia**. The timber value chain has three main links: the forest, the first transformation and the second transformation, leading to the final consumer. Its main actors are: indigenous communities, peasant communities, private landowners, companies with special temporary authorizations (ATE, former forestry concessions), local social groups (ASL) and service providers. The domestic forestry market represents between US$350 million and US$450 million by 2021. Markets are located in cities such as La Paz, Cochabamba, and Santa Cruz (construction, laminate-agglomerates, and furniture). The export market for timber products is recovering, and generates around US$70 million, although in the past it exceeded US$100 million. Flooring, furniture, doors, windows, and sawn lumber are the main export products.

- **Colombia**. According to the Forest and Carbon Monitoring System as of 2017, natural forest logging (59 million ha) is concentrated in the Amazon (35 million ha) and Pacific (8 million ha) regions; with 74 Forest Management Plans under approval and only 19 approved. Plantations (310,000 ha) are grouped in the Andean region (125,000 ha), the Caribbean region and the Orinoco region (67,000 ha each).[9] Production is transported to processing centers in capital cities. There, it is transformed into primary products, with low value added, such as sawn and brushed timber, boards, veneer sheets, containers, among other products.

- **Ecuador**. In 2020, 197 companies engaged in forestry and timber extraction were registered, 12% the Amazon region. Timber comes mainly from forestry plantations in the highlands and the coast (65% of the volume mobilized and marketed). The most harvested species were: balsa (*Ochroma pyramidale*), coffee walnut (*Cordia alliodora*), pigüe (*Pollalesta discolor*), sande (*Brosimum utile*) and chalviande (*Virola sp.*), pachaco (*Schizolobium parahybum*), and otoba (*Otoba novogranatensis*). There are four types of stakeholders involved in timber harvesting in the Amazon: farmers, intermediaries, transporters and forest managers. Timber harvesting is carried out by small farmers, settlers and indigenous people, with areas ranging between 30-80 hectares. Between 64-74% of households with forests receive income from timber sales. The native forest provides lumber for furniture and construction; boards, planks and pieces of various sizes go to sawmills and local and national warehouses. Roundwood timber goes to the plywood industry; locally, the furniture industry is connected with small sawmills and wood depots where sawn products from the forest are delivered.

- **Perú**. Links in Peru's forestry value chain include forest production processes, river transport, primary processing, major transport, reprocessing and marketing, but there are opportunities to become a complete, competitive and efficient chain that generates employment and profitability. Advantages include the large number of hectares that remain unused, its low standing value (stumpage fees), low labor costs, the relatively low cost of fuel (compared to Chile, Bolivia and Brazil) and tax exemptions on investments in the Peruvian Amazon maintained by the state. At least 50% of production is concentrated in six species: shihuahuaco (*Dipteryx sp.*), tornillo (*Cedrelinga catenaeformis*), cachimbo (*Cariniana sp.*), copaiba (*Copaifera paupera*), cumala (*Virola sp.*), and bolaina blanca (*Guazuma crinita*). The construction sector is the largest consumer of wood products (sawn timber, shingles, flooring, molding, etc.), mainly for formwork. The rest of the production was for the furniture sector. However, a FAO & ITP/CITE Madera (2018) study identified, for example, a potential demand ten times higher due to a shift in preference in favor of the use of wood for flooring in apartments. Of the total exportable timber supply, molded and shaped timber stands out, followed by sawn timber.

- **Venezuela**. In recent years, the Corporación Venezolana de Desarrollo de Guayana (CVG) has been promoting the use of natural rubber (*Hevea brasiliensis - Hevea benthamianea*) in the Atabapo municipality since the 1980s, based on the experiences initiated by the Ministry of the Environment in the 1970s; the program planted 325 hectares, 35 of which were producing latex.

9. Business plans of two forest clusters in Orinoquía, Meta and Vichada, Colombia, Office National des Forets Andina, Green Growth Mission ONF Andina (2018).

Non-timber forestry products (NTFPs)

- **Bolivia**. There has been an evolution in productive activities in the Amazon, from rubber and then the Amazon nut (*Bertholletia excelsa*) with high economic, social and ecological importance, as well as some promising fruits, such as açaí (*Eutherpe precatoria*), majo (*Oenocarpus bataua*) and copoazú (*Theobroma grandiflorum*). Amazon nuts are the most important value chain to develop to the fullest extent, due to their current magnitude and potential. It comprises the following links: collection in the forest (called 'zafra'), gathering and transportation, drying and processing, and finally, marketing in the domestic and export markets to the final consumer. The actors in this chain are gatherers or community members, independent middlemen, independent intermediary traders, contractors dependent on processing companies, and finally, the processing and marketing companies.
- **Colombia**. Non-timber forest products (NTFPs) have legal gaps, which is why Decree 690 of 2021 was enacted for the sustainable management of wild flora and non-timber forest products. It provides clearer rules, definitions, procedures and rights of the communities to market them legally with low transaction costs and standard measures (their estimation in relation to traditional ones) to facilitate their commercialization, thus bringing transparency to the process. Studies have also been conducted on promising species and the marketing chains of products from species such as the açaí (*Eutherpe precatoria*), canangucha (*Mauritia flexuosa*) and seje or milpesos (*Oenocarpus bataua, var. batua*). However, despite their potential, these chains have not gone beyond the formulation of strategies and studies, and are far from being consolidated, as is the case with timber.
- **Ecuador**. NTFPs and other forest product value chains have great potential for income generation and innovation. However, these chains are still in early stages of development, facing problems associated with their production, extraction systems and the development of marketing channels (poor product outlets, low prices, weak support infrastructure for exporting, limited capacity to respond to market demands). Nevertheless, NTFPs have contributed to the wellbeing of Amazonian populations, who have found in these products their main sources of livelihood and income-generation such as food, medicines, dyes, colorants, fibers, oils, resins, gums and construction materials. These products are the basis for bioenterprises that offer opportunities to diversify local livelihoods in a sustainable, inclusive and resilient manner (e.g., in the pharmaceutical, cosmetics and nutraceutical sectors). Among the main products worked with are: aguaje (*Mauritia flexuosa*), pejibaye (*Bactris gasipaes*), palm fiber (*Aphandra natalia*), ungurahua (*Oenocarpus batahua*), chambira (*Astrocaryum chambira*), annatto (*Bixa Orellana*), guayusa (*Ilex guayusa*), vanilla (*Vanilla sp.*), cacao (*Theobroma cacao*), white cacao (*Theobroma bicolor*), Andean cinnamon (*Ocotea quixos*), tree peanut (*Cariodendron orinocense*), dragon's blood (*Croton lechleri*), among others.
- **Perú**. Amazon nut activity is mainly located in the department of Madre de Dios. In 2019, almost 4 million kilos of Amazon nuts were produced (234 thousand kilos in shell and 3.6 million kilos of peeled Amazon nut), almost all for export. However, there is still significant scope for adding value up to packaging for final consumers and the manufacture of composite products with other ingredients. Other important non-timber products include shiringa, aguaje, and medicinal products such as cat's claw and copaiba, which are beginning to acquire great value. Along the same lines, aquaculture production in the Peruvian Amazon has increased significantly with nearly 4,000 tons of fish, of which 37% corresponds to tilapia, 8% to trout, and the remaining 55% to native Amazonian species (such as paiche, gamitana, and paco), which also have considerable potential (UNDP, 2017). By 2035, Peru has significant opportunities to value the forests of the Amazon and develop the emerging value chain of timber forest products, exporting and selling high-value-added wood products (dimensioned, dried, and finished parts and pieces, doors, windows, prefabricated houses).

- **Venezuela**. In recent years, non-indigenous producers in the Atures municipality have incorporated the cultivation of cocoa, copoazú and rubber trees, as well as manaca and pijiguao palm fruits, complementing the indigenous supply for commercialization in the local market during harvest periods. Local and indigenous entrepreneurs have initiated value-adding commercial experiences based on industrialization and product diversification, mainly for the local market and to a lesser extent for the national market. Regarding copoazú, products ranging from basic paste to oils, juices, jams, chocolates and truffles are offered in limited volumes due to the semi-artisanal production capacities and challenges in their commercialization. As for manaca and pijiguao palms, value is added by producing flour, pasta, canned fruit in the case of pijiguao, and juices, jam and wine in the case of manaca. These species have enabled modest entrepreneurship initiatives to transform them into products of commercial interest, and provide opportunities for the post-harvest use of species for timber purposes, particularly veneer and construction material, in addition to the use of the canopies for roofing, handicrafts and construction material, which has so far been underutilized, requiring investment in technological development and policies that favor their post-harvest industrial use. The utilization of the following resources is proposed: Amazonian fruit trees: cupuacu (*Theobroma grandiflorum*), tucupi (*Solanum sessiliflorum*), guava arazá (*Eugenia stipitata*), pineapple (*Ananas comosus*), Amazon nut (*Bertholletia excelsa*); (ii) palms: peach palm (*Bactris gasipaes*), manaca (*Euterpe precatoria*), moriche (*Mauritia flexuosa*); and (iii) aquaculture, ornamental fish, ecotourism, fibers, and handicrafts.

Box 7.2 Regional and global trends that can be leveraged

An emerging trend is taking place in several countries around the world, but it needs to be accelerated: the construction of high-rise buildings in wood. This development requires a shift from the use of a single species (for reasons of homogeneity) to a mixed-species system, in order to make better use of tropical forests.

HoHo Wien / Siga.Swiss Building, Austria

Source: https://www.madera21.cl/blog/2021/02/24/el-futuro-de-la-construccion-la-madera-como-material-para-edificios-en-altura-alrededor-del-mundo/

In view of the region's vulnerability to adverse weather events, it is useful for the countries to have a stock of prefabricated wooden constructions with houses, health clinics, schools, shelters, among others.

Prefabricated wooden house, Santa Fe, Argentina

Source: https://www.unosantafe.com.ar/santa-fe/crecida-del-parana-comenzo-la-construccion-viviendas-emergencia-n2065200.html

Another interesting solution for the Amazon, based on residues from forests and the forestry industry, is the generation of energy and heat, avoiding the problems of interconnected systems in remote areas. One example is Precious Woods in the Brazilian Amazon, which supplies energy to its own industry and to the nearby town of Itacoatiara.

Forest residue-based power plant

Source: https://acervodigital.ufpr.br/bitstream/handle/1884/32733/JOSE%20LAZARO%20PINHEIRO%20DA%20SILVA.pdf?sequence=1&isAllowed=y

Revitalizing the forestry sector implies establishing new governance at the policy, legal and institutional levels. It is imperative to transition from a philosophy of command and control (which has yielded very modest results) to one of encouragement and promotion, with an appropriate balance between protection and utilization. The new governance should include several elements:

a) **Strategic positioning** that shows that environmental conservation and protection is not incompatible with logging natural forests, reforestation and the development of the forestry industry, provided that this is approached following principles of sustainability.

b) Joint work with the different **interest groups** related to natural resources.

c) Establishment of an **autonomous authority**, capable of making decisions at the central, regional or departmental level, to streamline procedures and excessive time delays and to incorporate the use of technology at the service of the sector's stakeholders.

d) Modification or revision of **forest management schemes**, forest plantations, forest industry, markets and ecosystem services.

e) Reformulation or adaptation of the **forest concession systems** using lessons learned from the past as well as experiences from other successful countries.

f) **Capacity** building that should be incorporated into the process.

Regarding human resource training to support and promote the forestry sector, forest engineering is a relatively adequate field, but requires academia's research support. Academia and the vocational education system (technical and professional) should be closely linked. To this end, it is necessary to:

- **Determine the needs of personnel** at different levels (worker, technician and specialized professional) in forest management, plantations and forest industries.

- **Plan personnel training** in the above-mentioned areas with the establishment of medium- and long-term topics and budgets.

- **Establish public-private-academic cooperation agreements** for personnel training and subsequent specialization, both abroad and locally.

- **Establish or strengthen regional training centers** in the Andean-Amazon countries to undertake part of these tasks.

- **Design, finance and implement a scheme of professional internships** in the best developed companies and in all areas of forestry, industrialization, and the design and marketing of both timber and non-timber forestry products.

Finally, the macro-level planning of the sector, project preparation, market research, measuring employment impacts, and the modification of policies, laws, and regulations require access to high- quality, continuous, up-to-date, publicly accessible information that is constantly evolving. For this purpose, the first step should be the assignment of responsibility for updating and coordinating the information to a specific unit within the state institutional system for the forestry sector. An additional element is that this unit should also work with big data to address specific queries on variables that have fundamental international bases to identify potential new products and potential new markets.

Box 7.3 Success stories

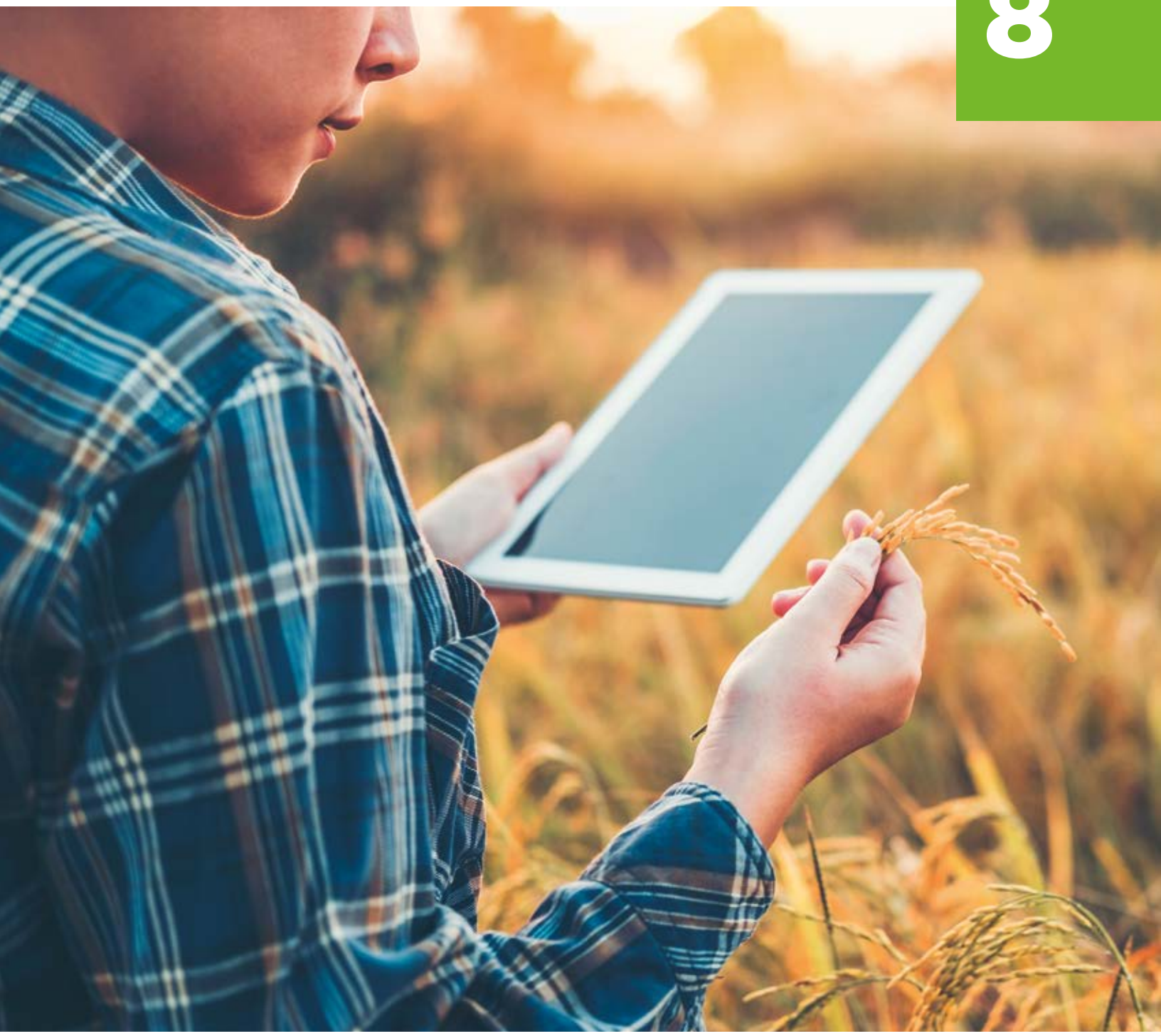
Andean-Amazonian countries have had success stories in the management of their natural and planted forests in tropical and Andean areas, but have lacked continuity in institutional, legal, technical and financial support. These experiences have all been successful, some continue and others not, but these countries have learned greatly, which makes it possible to think about the recovery and expansion of the experiences with the necessary adaptations for the immediate future. Some representative cases can be cited:

- In **Ecuador**, in the field of forest plantations and adding value, particleboard[10] and fiberboard have led the country to its positioning and consolidation as an important exporter in Latin America, due to large investments allocated to sources of raw material, new machinery, existing and diverse markets, as well as product differentiation; another interesting example is the development of plantations and industrialization of balsa wood from natural forest and plantations, in which numerous companies have participated. While of high value, this niche is limited in area.
- In **Bolivia**, more than 7 million hectares were successfully managed in private forestry concessions in the Amazon. At one point, Bolivia was the country with the highest number of voluntary certifications of good forest management (FSC®) in natural tropical forests. In addition, the harvesting of non-timber forest products, such as Amazon nut, has acquired considerable relevance and is an important export item.
- In **Venezuela**, the experience of the Compañía Nacional de Reforestación and its continuation by the state-owned company FORESTOR succeeded in reforesting nearly 500,000 ha in the eastern savannas of the country on the north bank of the Orinoco River between 1970 and 2000. This activity not only focused on developing successful Pinus caribaea plantations, but also on building an important value chain.
- In **Peru**, forest concessions have been granted for approximately 7.4 million hectares over the last two decades. The results of these forest management concessions have been variable, but some of them have been referred to as model cases in the PCM, USAID, US Forest Service report (2021b).[11]
- In **Colombia**, Cartón de Colombia has developed outstanding experiences in both forest plantation (mainly with Acacia mangium and Pinus patula species) and secondary forest management. Considerable areas have been planted successfully, introducing species and applying quality silviculture. Regarding natural forests, the company managed the Bajo Calima secondary forest concession, achieving a complete rotation, but the concession subsequently expired and there was no adequate handover to the local communities.

All countries studied have great potential to activate their forest economies (forest engines) with natural forest resources that are found in a large part of the territories in idle conditions, in varying degrees depending on the areas of each country, and even outside the regions established to remain under forest protection or conservation.[12]

10. Boards made from small pieces of wood or other lignocellulose materials (e.g., chips, flakes, shavings, etc.) agglomerated by means of an organic binder and one or more of the following agents: heat, pressure, humidity, catalyst, etc. https://www.fao.org/3/i2080s/i2080s08.pdf
11. Maderera Río Acre [MADERACRE] (forest management and industry); Maderera Yaverija [MADERYJA] (forest management and industry); Forestal Otorongo (forest management and industry); Asociación para la Investigación y Desarrollo Integral [AIDER] (associativity and technical assistance); Reforestadora Amazónica [RAMSA] (forest plantations; Reforesta Perú (forest plantations); AIDER - CITE Indígena (handicraft and furniture industry); and Triplay Martín S. A. [TRIMASA] (plywood industry), which manages and coordinates logging operations in native community forests (CCNN).
12. According to the IUCN definition, 'conservation' is understood as the proper management and utilization of the forest resource, rather than its untouched preservation.

8



ANDEAN AGTECHS

8. ANDEAN AGTECHS: EXPANDING THE FRONTIER OF AGRICULTURAL TRADE POSSIBILITIES THROUGH TECHNOLOGY

8.1 Introduction

Latin America (LA) has a long tradition of producing raw materials and foodstuffs, many of which are traded worldwide. Support for the agro-industrial sector has focused on expanding agricultural production, creating jobs in rural areas, increasing agricultural productivity, boosting the integration of MSMEs into value chains, expanding agricultural exports and generating foreign exchange, and improving environmental practices. However, developing chains with international competitive power has been limited to a few success stories in the larger countries of the region (Crespi *et al.*, 2017).

The use of technology and innovation in this sector has given way to a new universe, called Agritech[1], which includes a wide range of new technologies applied to agriculture to increase its efficiency, productivity and sustainability. Approximately ten years ago, a series of ventures based on innovative technologies called Agtechs began to vigorously emerge, providing knowledge-based services (KBS) that, through the use of innovative technologies (especially digital), make various processes along agri- food value chains more efficient, reduce environmental impact and, in some instances, contribute to the development of new products, such as bioenergy, biomaterials, new foods, among others (Bert, 2021; Lachman and López, 2019). These processes may involve tasks such as planting, irrigation, fertilization, crop protection, early detection of diseases in crops or livestock, etc., or services related to logistics, marketing, traceability, financing, among others.

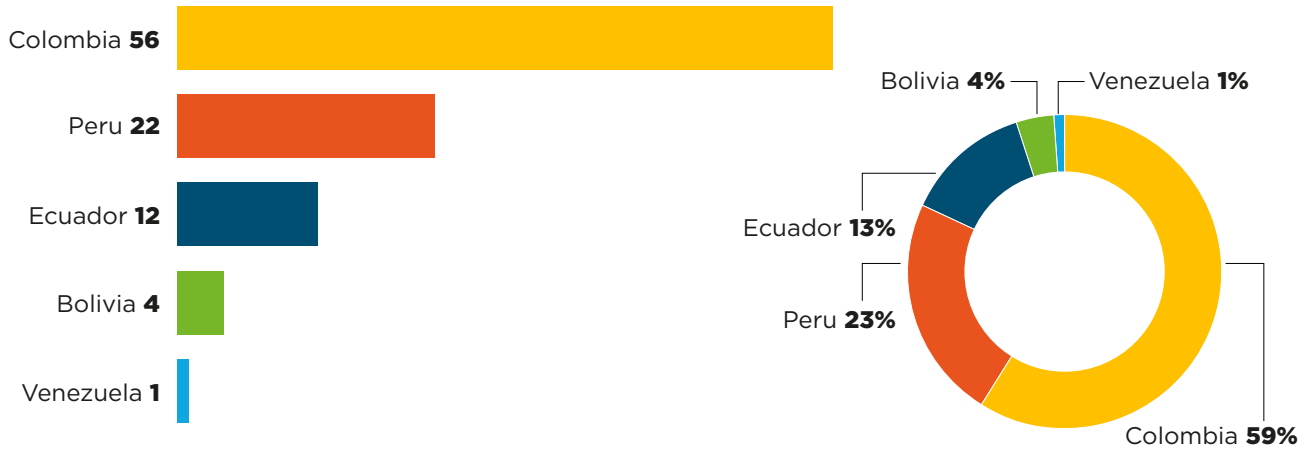
Emerging technologies, such as Big Data, artificial intelligence, Internet of Things (IoT), blockchain, among others, can be applied to various links in agricultural, livestock or agroindustry chains (World Bank, 2021; FAO, 2020). In general, digital services make it possible to increase yields, reduce the use of inputs (thus improving environmental impact), and can also provide transparency throughout the chains, for example, for certifying compliance with good environmental practices or connecting end consumers with producers at the beginning of the chain (Lachman *et al.*, 2021; Liu *et al.*, 2020).

More than 450 companies with these types of developments have been identified in LA, of which more than half had, at the time of the survey, less than four years of establishment (Vitón *et al.*, 2018). This study intends to provide an update on the context and status of Agtechs, with a focus on the Andean region. Ninety-five Agtech[2] ventures were identified, which are offering services on various links of the value chain; most are based in Colombia and Peru, followed by Ecuador, Bolivia and Venezuela[3]3. These countries are characterized by a relatively diversified agricultural structure, where extensive annual crops, multiannual crops and livestock activities coexist, with a significant weight in employment generation and exports. In

1. Harnessing technology and technological innovation to improve efficiency and yields in agricultural processes.
2. All of these recently emerged companies have websites and/or are present in various social networks specialized in the subject.
3. Refer to the Annex for a brief description of the methodology.

tune with this characteristic of the region's agricultural production structure, Agtech solutions are varied, meet diverse needs faced by local agri-food chains and contribute to improving productivity and, in many cases, mitigate environmental impact.

Figure 8.1 Survey of Agtech companies in the Andean region (95 cases)



Fuente: elaboración propia.

There is a concentration of companies in the E-commerce/Marketplace axis (i.e., digital platforms for the commercialization of products or inputs), with 35% participation, followed by Smart farming[4] with 24% (i.e., solutions for the optimization of farm management processes/production activities) and Fintech (11%). In this category, ventures aimed at capturing more value for the agricultural producers, either through greater value chain integration or through facilitating commercial channels, without participating in the operation, were surveyed.

Companies offering e-commerce services market a variety of products, including fertilizers and seeds, as well as services such as specialized storage and packaging, among others. Platforms within the Smart farming segment mainly comprise a series of technological solutions aimed at improving technological management of crops or livestock, enabling producers to optimize production processes. A certain degree of heterogeneity is perceived in the advancement of technology and/or in the specific focus that some ventures have, such as machinery services management. Two out of the twenty-three ventures offer digital services for the livestock sector. These types of platforms partially or fully encompass four operational phases:

4. Smart farming consists of managing farms using modern information technologies to increase the quantity and quality of products while optimizing the use of human resources. Among the technologies explored are sensors, specialized software, georeferencing and geolocation technologies, robot tractors and large-scale data processing.

1. Generation and/or collection of external and proprietary data through sensors, IoT, meteorological stations, and climate data, images (satellite, drones, cameras), digital production records, etc.

2. Provision of services through applications or other digital platforms (such as websites).

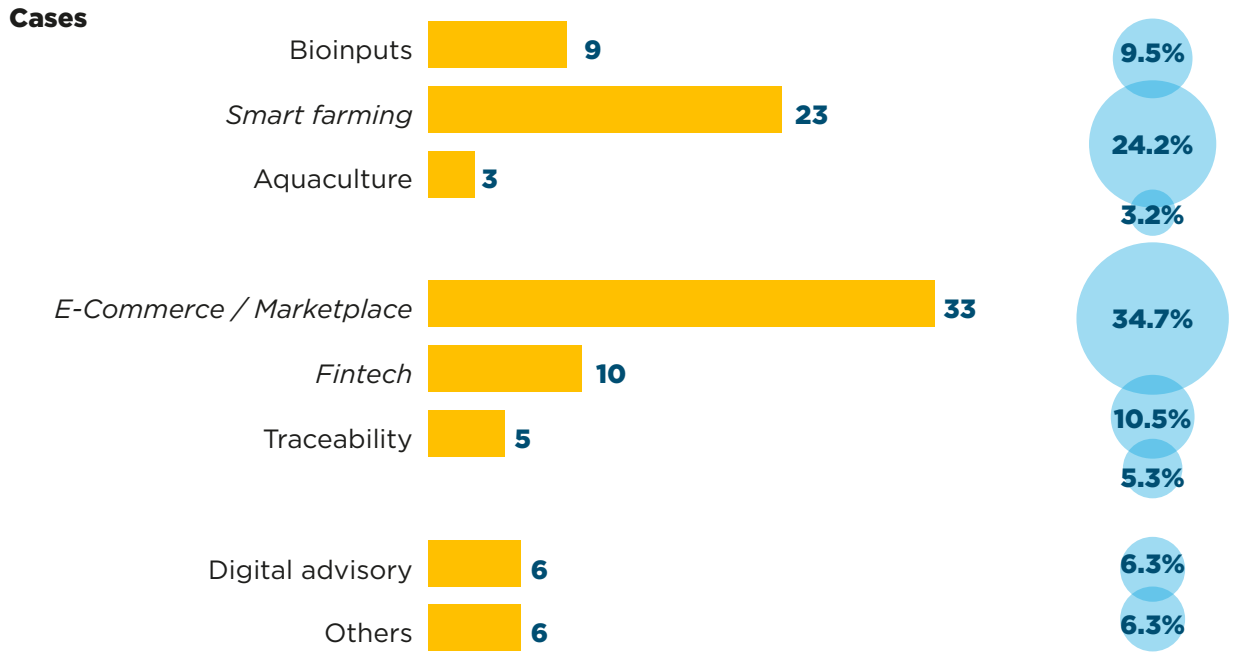
3. Design of evaluation, diagnostic, and monitoring systems: tracking crop conditions, monitoring sanitary status, diagnosing nutritional deficiencies, analyzing water conditions, measuring environmental conditions (temperature and humidity), generating spectral indices, land use and occupancy mapping/contour lines.

4. Alert systems and recommendations aimed at achieving improvements in agronomic management: timing for phytosanitary control, environmental conditions for applications, crop productivity, work planning, mapping/zoning, soil map-based agronomic recommendations, etc.

Companies within the Fintech axis focus on offering services geared to streamlining credit evaluation processes, making credit available to small farmers, linking up with investors and improving access conditions. However, there are differences in the business models used.

Finally, the remaining five axes are completed by companies in other areas, such as bioinputs, aquaculture, consulting or digital technical assistance. In general terms, the ventures could be grouped into on-farm inputs and services, accounting for 37% of cases, and marketing and financing, representing 51% of the surveyed companies.

Figure 8.2 Agtechs by sector/axis



Source: Own elaboration

Note: bars indicate the number of firms identified in the respective sectors/axes, while the percentages in each of the circles to the right of the graph show the share of each sector/axis in the total number of Agtech firms in the region.

8.2 Addressing the main challenges for Agtech growth and expansion

Around one hundred Agtech ventures were identified in the Andean region which are offering services to the various links along the value chain of the agricultural sector.

Agtechs in LA, and particularly those in the Andes, face several challenges to their growth, replicability and consolidation. These are related, among others, to an immature entrepreneurial system, limited internet connectivity in rural areas, difficulties in the use of digital tools and distrust by users, limited digital skills among users, lack of financing for technology-based companies, as well as limited knowledge of the agricultural sector. Regulatory issues also represent barriers for these types of ventures.

Promoting digital transformation and capturing the multiple benefits of these technologies requires identifying the factors that limit and promote their development (supply factors), as well as understanding the causes that delay their incorporation and adoption by the different stakeholders in the chain.

Following are some of the challenges that Andean Agtechs face for their expansion:

- **Poor maturity of the local entrepreneurial ecosystem.** While the growth of ventures has accelerated in recent years, aspects such as hiring staff for digital systems tasks present a great difficulty. Simultaneously, the supply of financing for technology-based ventures is also much more limited and restricted compared to other countries, such as the United States, Brazil, the United Kingdom, Israel, among others.

- **The lack of digital infrastructure and connectivity in rural areas is considered a major limitation.** While several Agtechs have been able to solve the problem by developing platforms that operate offline, there are certain additional functionalities that could have been introduced if there was internet connectivity, such as: real-time alerts, direct cloud storage without consuming cell phone memory and making it possible to work with larger files, and other functions.

- **The delay in the use of digital tools in the agricultural sector,** and particularly the lack of standardization of production processes, hinders the integration of small producers into large global supply chains. Given that the incorporation of these technologies implies a change in certain production routines, many entrepreneurs decide not to adopt them, at least in the short term. However, progress has been made with the incorporation of new generations and the acceleration of changes in demand brought about by COVID-19. In that respect, public policies should continue to support the development of programs that allow producers to improve their possibilities of adopting digital technologies, enabling them, for example, to certify their agricultural practices, identify elements to address specific high value-added niches, etc.

- **Lack of digital skills.** This also affects the creation of new business models. A large number of potential clients are perceived to be self-excluded because they consider that digital solutions offered by certain Agtechs require specialized knowledge or are difficult to incorporate into their processes. However, new trends regarding consumer demands, for example, in terms of sustainability and traceability

throughout the chain, are promoting the use of these types of platforms. Thus, the importance of providing simple, intuitive and user-friendly solutions is emphasized. Several Agtechs are already working on improvements in terms of user experience. At the same time, technical support teams are key elements to ensure that customers can quickly use the full potential of the services provided.

- **Mistrust of new digital-based technologies among rural producers.** In particular, the concept of acquiring goods and services through marketplace platforms has been validated in cities, but has not yet been accepted in rural areas. While this process is changing over the years, there is still some resistance among producers, but also, from operators in some cases, to using these devices in their activities. Countries such as Argentina and especially Brazil account for a growing phenomenon in which digital platforms are beginning to be used more continuously.

- **Limited incentives to using digital tools.** There are Agtechs that have already implemented incentive mechanisms: (i) quarterly prizes for "best users" of the platform; (ii) cashback schemes with companies, with a percentage of the contract that is used to promote the use of the platform among operators (for example, 10% is used for prizes for the most frequent users, including trips, tablets, cell phones, among others).

- **Poor access to external financing for entrepreneurs.** A key factor is the lack of external financing sources, for example, Venture Capital, to provide the necessary funds to support the expansion of this type of companies. A substantial part of resources invested in developing the platforms comes from their own funds.

- **Difficulty in recruiting professional profiles with the required skills.** Although the most required skills are those relevant for technology development, the lack of technical and agronomic knowledge ultimately affects the quality and predictability of the supply of services based on agricultural knowledge. These types of ventures also face limitations in terms of human resources due to their capacity to pay salaries, while generating interest through other aspects such as growth projections and targeting younger profiles represent other challenges.

- **Ensuring information sovereignty and safeguarding ownership of generated data.** Several Agtech companies have successfully implemented software that utilizes blockchain technology to ensure security and transparency in the flow of information.

- **Low levels of banking access or financial inclusion.** Seventy percent of producers use only cash, so financial Agtechs face barriers to market penetration. The cost of commissions is also an impediment to accelerate the adoption of digital means of payment.

- **Few opportunities for technological co-development partnerships with universities or other local science and technology institutions.** This factor implies that all technological development, testing and validation are carried out with in-house capabilities and knowledge, without being able to take advantage of external sources, as is the case in other countries (United States, Australia, Israel, or Europe), where it is common for companies to rely on the experience and trajectory of science and

technology institutions. Bringing the platforms closer to students of careers related to agronomy and implementing internship programs that attract future professionals is imperative.

- **Competitiveness of the products themselves and of the entrepreneurial ecosystem.** Several Agtechs face competition from companies offering similar services from other countries with more experience in the development of biotechnology products (mainly the United States), which implies having to compete on price.

- **Regulatory aspects.** These also pose a challenge for product approval, considering that systems in different countries have processes designed mainly for approving certain agricultural products, such as chemicals.

- **Resources and public support for R&D.** Financial resources and support from government institutions remain limited compared to other countries, which slows developing innovations, especially if they require R&D funds.

8.3 Agtechs are here to stay: opportunities for development in the Andean region

In order to illustrate the opportunities found in the development of Andean and Latin American Agtechs, some case studies are presented that cover aspects such as the initial process and the current situation, technology development, business models, user types, impacts on competitiveness, and future prospects.

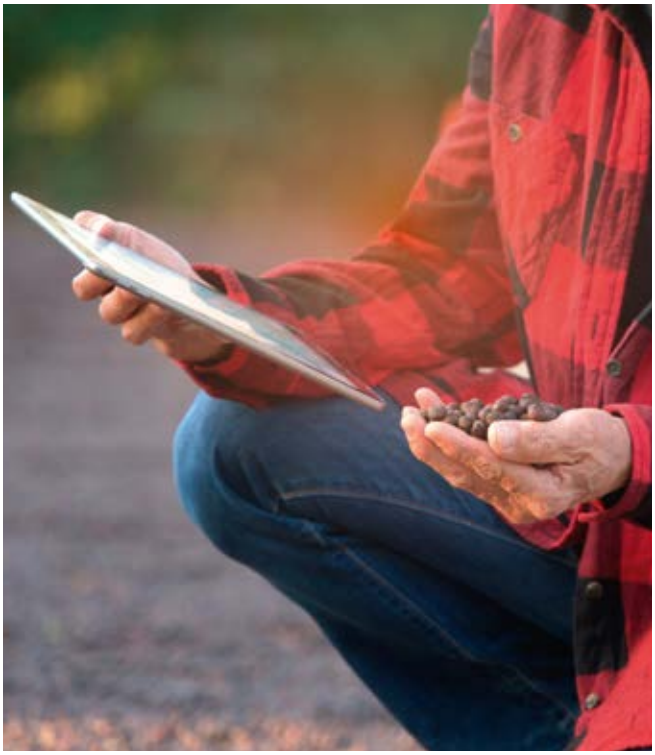
Common aspects of the local ecosystems that facilitated the emergence and creation of these companies and the use of their technological proposals are identified. For this purpose, the potential impact of Agtech on (i) the sustainable development of agrifood systems and the current scope and (ii) the projection of the venture, was evaluated. Each company was assessed according to the following parameters:

To promote digital transformation and capture the multiple benefits of Agtechs, it is necessary to identify the factors that limit and promote their development.

A. Economic axis:

1. Relevance in the market. Current and potential participation, degree of coverage or penetration that could be achieved.

2. Expected economic benefit. Economic impact in terms of productivity and production, quality improvements, input savings, among others, with a micro valuation (company or producer level) and sectoral valuation (macro impact on the sector).



B. Social axis:

1. Inclusion of stakeholders. Opportunities that technology offers for the productive, commercial, technical and/or gender integration of different stakeholders in agricultural chains.

2. Contribution to employment. Impact on the generation of new jobs as a result of the development of a product, sector or region.

C. Environmental axis:

1. Environmental impact. Impacts on the environment by increasing efficiency in the use of inputs, contributing to biodiversity conservation and climate change mitigation, as well as soil and water conservation, etc.

The evaluation of these aspects for each Agtech, using a simple quantitative scale,[5] allowed the initial ranking of the 95 ventures, which served as the basis for selecting the case studies. While the selection process is not shown in detail in this chapter,[6] it is concluded that eight case studies originating in the Andean region were chosen, to which two companies originating in Argentina and Brazil, but with operations in the region, were added. These two companies also represent mature, highly internationalized experiences in the LA region and have relevant links with other stakeholders in the entrepreneurial ecosystem.

5. Each variable was evaluated with a score between 1 and 3, according to a low or minimal/high or outstanding contribution.
6. See Annex for details of the selection.

BloomsPal Market Network

BloomsPal
Global Agricultural Trade

Origin: Colombia

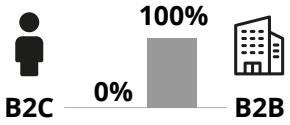
Foundation year: 2020

Value proposition: linking individual producers and cooperatives with buyers through sourcing software, centralizing direct negotiations and all operation processes through a single channel.

Operations in other countries (most important):
Costa Rica. United States.

External financing (USD):
100,000

Business model:



Users / clients:
520

Revenue (USD):
500,000

Direct employments:
24

Barriers:
- Technification and agronomic knowledge.
- Connectivity.
- Use of digital tools.

Prospects:
- Positioning as a global platform for the export of agricultural products.

Users, jobs, revenue, capital received: estimated 2022.

Approximately 45% of flower crops destined for sale are discarded before they generate revenue. BloomsPal Market Network was created in 2020, with a value proposition that aims to link individual flower producers and cooperatives with buyers, through a sourcing software, centralizing in a single channel direct negotiations and facilitating all the processes of the operation (logistics services, financing, integrated payment management, data reconciliation, reporting and analysis, among others). Users can freely negotiate prices and conditions of sale of agricultural products on the platform, including the possibility of contracting the various additional services offered by the company. In addition, based on historical records of completed transactions and the reputation of producers, the company recently added to the service of financing through advance payments so that its customers can obtain working capital funds at a low cost, thus overcoming difficulties associated with the seasonal nature of the business.

The company charges a fee for the purchase orders received by producers through the platform, who pay between 3% and 5% of the total amount. In turn, it generates resources from the logistics services it offers; in addition, the company also generates income from financing services (through advance payments) and cargo shipment insurance.

The user portfolio is diverse. Among the farmers, 50% are family-owned (with farms of up to 5 hectares), 40% belong to medium-scale farms, and only 10% of the clients can be considered large- scale producers. BloomsPal Market Network is used in Costa Rica, the United States and Colombia.

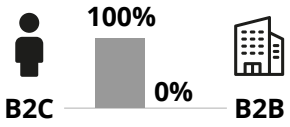
In 2022, the company became the largest online platform for the international flower trade, with Australia as the main destination. Through the use of its platform, up to 40% of waste can be reduced, while grower income can be increased twentyfold. Over the next three years, BloomsPal aims to become the main hub for connecting flower growers and other high value-added products (e.g., aromatic herbs, fruits and vegetables) operating from Latin America with their buyers in the rest of the world. Furthermore, in the medium and long term, the company aims to position itself as a leading platform to promote the exports of any type of agricultural product from the region to the world.

Agros

Origin: Peru

Value proposition: to provide a digital identity to family farming producers and the rest of the stakeholders in the chain, in order to rebuild and strengthen social capital.

Business model:



Users / Clients: 5,000

Revenue (USD): 100,000

Foundation year: 2020

Potential in other countries (mainly):
Colombia. Mexico.

External financing (USD): 600,000

Direct employments: 20

Barriers:
- Farmer's distrust to new technologies.
- Lack of incentives for the adoption of digital tools.

Prospects:
- Extending the reach of digital identity.
- Development of complementary tools.

Users, jobs, revenue, capital received: estimated since 2019.

Agros was founded in the rural interior of Peru (Piura) and currently has 5,000 users in the country, distributed in eight regions, covering highland, coastal and jungle areas. Its value proposition is to provide a Digital Identity to family farming producers and the rest of the stakeholders in the chains and, on this basis, to strengthen and rebuild the social capital reflected in bonds of trust. The Digital Identity has an impact from a gender perspective, seeking to encourage corporate stakeholders to expand the supply of microcredits to small-scale agricultural establishments headed by women.

Applications are self-developed with blockchain technology, where all digital identities and actions (relationships) carried out by participants are validated through other official sources of information or other physical supports. Relationships and interactions that occur between the members of the ecosystem are recorded through the platform, by issuing certificates that support the producer's actions and history of operations. Certificate issuance has its own validation system through GPS or documentary support, in addition to using a decentralized reputation algorithm. Producers can thus relate on more favorable terms with companies and organizations in the sector, and vice versa. This translates into greater commercial opportunities: from access to inputs at better prices and better product sales prices to gaining access to specific market niches. Moreover, suppliers can access information generated by other suppliers (with the prior approval of the producer involved) and gain a more detailed knowledge of the profile of their customers. The platform includes information digitization tools.

Considering that 25% of people have analog cell phones, registration and operation services for agricultural producers can be conducted through an interactive voice response (IVR) system that allows them to validate information, share their identity, contact suppliers, apply for credit and manage other services, such as medical consultations. The WhatsApp alternative was developed to avoid the extra cost of adapting to another application. Corporate actors have access to a more extensive platform, available for computers and smartphones

The company is supported by charging a fee to its corporate clients for the use of the platform (from USD 100 to USD 150) and an additional fee for accessing the producer's identity (USD 3), while it is testing a freemium model with some cooperatives (free of charge if they issue certificates). Processing the Digital Identity and participating in the ecosystem is free of charge for the producer.

One of the main objectives for 2023 is to reach agreements with global players to also operate in Colombia, Ecuador, Guatemala and Mexico.

AGP Geospatial Company

Origin: Ecuador

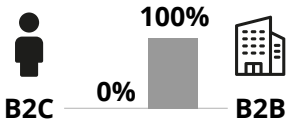
Foundation year: 2016

Value proposition: development and applications of geospatial tool for digital agricultural management, basing decision making on objective and reliable information.

Operations in other countries (mainly):
Mexico. Colombia.

External financing (USD): 0

Business model:



Users / Clients: 50

Revenue (USD): 230,000

Direct employments: 10

Barriers:
- Digital gap.
- Public-private technology transfer system with limited scope.

Prospects:
- New product development: issuance of certifications, carbon footprint measurement.

Users, jobs, revenue, capital receied: estimated 2022.

This is an Ecuadorian startup, whose value proposition is focused on the development and application of geospatial tools for agriculture, providing services such as: data capture and satellite or drone imagery; generation of certification of good agricultural practices in specific crops; deforestation studies; capture of farm data (farm mapping, land occupation, use of inputs); reports, alerts and recommendations on plant health, land occupation, fertility status, suggested positioning of traps to capture pests, etc. The business model is based on project-based orders, some of which subsequently evolve into longer-term services and allow for charging an annual subscription. The company receives external support from Airbus, PCI Geomatics and Catalyst, and holds cooperation agreements with fourteen universities. It is one of the few ISO 9001-certified companies in Ecuador.

The clients stand out as large companies (or business chambers) and public and private organizations. The companies offer some of their products — such as services to farmers, for example — as a brand loyalty strategy. Almost 50% are foreign companies, exporting services and products to Malaysia, the United States, the United Kingdom, the Netherlands, Colombia, Mexico and Peru.

The main projects, covering different technology and process solutions, include the following:

- **SATAgro:** geospatial and two-way communication system that generates personalized intra-farm recommendations to improve the adoption of sustainable agricultural practices and integrate producers into value chains.

- **Geo Fertilidad Imbabura:** software that allows the generation of macro and micro nutrient maps that, combined with biophysical thematic maps, evaluate fertility status.

- **Smart agro:** project for the analysis of the sanitary status of banana crops on the Ecuadorian coast, improving disease, weed, and overturning management.

- **Land Use Change Mapping Service:** land use change study to monitor deforestation, mainly in oil palm.

Three medium-term projects are in the pipeline: (i) "Field Book", aimed at automating the issuance of certifications of good agricultural practices in the international trade of fresh and processed foods; (ii) estimation of the carbon footprint to issue certifications on the environmental impact generated by sector stakeholders; and (iii) generation of a climate vulnerability and disaster exposure forecasting system for various regions of the planet.

Agrocognitive

AgroCognitive

Origin: Venezuela

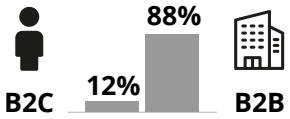
Foundation year: 2020

Value proposition: incorporate precision agriculture services to contribute to a more efficient agriculture, supporting sustainable and profitable food production for the producer.

Operations in other countries (mainly):
Paraguay. Colombia (potencial).

External financing (USD):
40,000

Business model:



Users / Clients:
1,360

Revenue (USD):
49,200

Direct employments:
5

Barriers:
- Digital technology adoption speed.
- Availability of financing.

Prospects:
- Customer and user quantitative consolidation.
- Expanding presence in LATAM.

Users, jobs, revenue: estimated 2022. Capital received: estimated since 2018.

Many production decisions that farmers make on a regular basis are not supported by objective data. Moreover, given the difficulties in monitoring large surface areas, it is common for problems in the production process (pests, herbicide-resistant weeds, etc.) to be detected late. This results in efficiency losses and higher production costs.

The Venezuelan company Agrocognitive provides precision agriculture services for extensive crops through a digital platform, mitigating the following challenges: (i) the need to adequately monitor crops is limited by the lack of personnel in the field; (ii) improving yield and efficiency by using good agricultural practices; and (iii) the supply of inputs is limited in terms of availability and price.

The service is based on a web platform, accessed through a mobile device or computer, which integrates external data sources -satellite images, meteorological data, photosynthetic radiation data, soil information, contour lines- with information provided by the users (i.e., that generated by the agricultural machinery). Using these large volumes of data, the application offers yield analysis (historical and forecast), derived calculations (NDVI, NDWI and others) to monitor current yields, early detection of sanitary disorders, as well as to propose recommendations for the mitigation of these disorders or, even, other types of prescriptions related to the application of inputs (e.g., seeds, fertilizers, herbicides, etc.). The platform can be operated in off-line mode. Once the grower is in an area with an internet connection, the subsequent process includes synchronization and reporting of actions. The application is available for extensive crops such as corn, rice, soybean, sorghum and sugarcane. Average measurements obtained to date show an increase of up to 15% in farmer income, 18% higher yields and 26% savings in the use of inputs.

Growers can access a basic service that provides binary sanitary diagnosis functionalities (affected or not), weekly download of spectral images and access to yield reports (historical and projected). Monthly cost is USD 50 for areas of less than 500 hectares and there is a 30-day free trial period. The advanced service also provides details of the type of disease and location, the possibility of requesting images on demand and access to other indicators such as evapotranspiration. Access to this service costs USD 75

per month for areas of less than 500 hectares. Currently, 40% of clients have a paid subscription. In 2022, a B2B model was incorporated, with distributors reselling the Agrocognitive service subscription, while alliances were generated with input suppliers in order to resell the platform. The company has closed agreements or is in the process of doing so with players in Paraguay, Honduras, Nicaragua, Costa Rica and the Dominican Republic.

The company has four types of clients: the main segment is composed of independent growers with medium-scale farms (from 20 hectares to 2,000 hectares), specializing in extensive crops; small growers' cooperatives, which purchase the service for a block of hectares that they then deliver to their members; food processing industry sectors (e.g., sugar mills); and financial intermediation or input sales companies (e.g., seeds) with financing and payment in products. The portfolio comprised 20% of clients in Venezuela and 80% in Paraguay (in 2023, the goal is to enter the Colombian market).

The plan is to reach 1,200 independent producers (covering 15,000 hectares) and double its reach in cooperatives by 2023. The goal will be to expand its presence in LA where there are 120,000 potential users, and move towards a collaborative software model, in which they can - through API (Application Programming Interface) - enable other developments to be used in a complementary way with the platform.

Hola Tractor

Hola Tractor

Origin: Bolivia

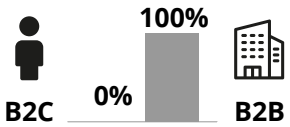
Foundation year: 2020

Value proposition: linking farmers demanding machinery services with others having equipment available for rent, facilitating greater technification and generating extra income for the owners.

Potential operation in other countries: Mexico. Colombia.

External financing (USD): n.a.

Business model:



Users / Clients: 250

Revenue (USD): 500,000

Direct employments: 7

Barriers:
- Resistance to the adoption of digitally based technologies.
- Availability of financing.

Perspectivas:
- Development of complementary services: digital wallet and insurance.
- Alianza Alliance with machinery suppliers to facilitate purchasing.

Users, jobs, revenue: estimated 2022. Capital received: estimated since 2018.

Hola Tractor is a Bolivian venture that offers services through a mobile application, by connecting agricultural producers who demand machinery services with those who have equipment available for rent. For small and medium-scale farmers, this creates the possibility of accessing a greater range of options and higher levels of technological advancement. On the other hand, the equipment owner benefits by generating extra income for their machinery, effectively establishing an additional business unit. The value proposition includes identifying and convincing and including owners of tractors or other machinery to offer their services and earn rent on those assets. The objective is to: (i) reduce idle time from 80% to 60%-50% of the useful life; (ii) foster women's involvement in the chain, either as owners of tractors or as independent service aggregators, acting as external partners of the company; and (iii) improve mechanization practices: the greater availability of planting and harvesting equipment generates 15% to 20% improvements in production, due to the use of appropriate machinery. In addition, there is a reduction in the use of inputs and environmental impact.

Access to services is provided through a self-developed application, which has two versions. On the one hand, the machinery-demanding producer can register with his personal data and view the availability of equipment in his area. In the case of owners, the second version of the application allows for registration and offer of machinery with the characteristics of the equipment (with photo) and details of the services available, as well as access to other features, such as GPS geolocation. During registration on the platform, Hola Tractor plays a central role in the validation of individuals and verifying personal data, through contact with both parties via telephone or message, which is a requirement to complete access and be able to offer and contract services. This function reduces the risk of fraudulent transactions and is considered key to ensure a successful link between supply and demand. When the request for the service is made, the company is responsible for monitoring the entire process, including the arrival of the equipment, the start of the work, completion and compliance. In addition, they are responsible for the collection and payment, which is currently done in cash and may also include the bank transfer.

Contracting the machinery presents alternatives depending on the demand; there are operations per hectare or per hour, which include or not the equipment operator. Depending on the type of contract, the payment method is also defined, with a fixed or variable rate for each linkage made.

The company has partnerships with ten associations, which allows it to scale the potential supply to almost 10,000 farmers. Working with grower associations makes it possible, among others, to shorten the validation process by incorporating the databases of associated farmers, which serves as a back- up for operations. Users are generally small and medium-scale producers (up to 50 hectares), distributed in three agricultural zones and specializing in four crops: soybeans and corn in the Santa Cruz region, quinoa in the Andean region (5,000 producers in the area) and sugar cane. Customer regional distribution is an advantage in terms of labor windows, and machinery between zones (north and east) can be rotated according to the season. It also allows the supply of equipment to be separated and offers the farmer what is needed for each crop. Small-scale farmers, especially in the Andean region, face adverse geographical environments, dependence on a single crop (quinoa) and lack of mechanization, so Hola Tractor improves access to equipment, especially for harvesting.

In 2022, the platform had 200 farmer users demanding services and 50 to 60 equipment owners. The company foresees accelerated growth in 2023, taking into account the alliances made with the National Association of Wheat and Wheatseed Producers, the National Association of Quinoa Producers and associations of sugarcane producers, totaling close to 40,000 growers. Hola Tractor's goal is to reach 10%-15% of this market.

Prospects for reaching markets such as Mexico and Colombia are in the pipeline. The company is working on migrating the cash payment system to a digital wallet scheme and on reducing the risk of equipment mobility by adapting an insurance system for transportation. An additional business unit is to facilitate the link between equipment owners and machinery suppliers, using Hola Tractor tools to improve access to credit. In addition, the company is working with development financing funds, such as the Banco de Desarrollo Productivo de Bolivia, for adding complements to the platform that will make it easier to generate a business plan (costs, profitability, etc.).

In the future, the current value proposition could be complemented with the provision of services to agricultural mechanization centers, which could be the owners of the machinery themselves. The company's role in these cases would be to facilitate links between the owners and the granting of the Hola Tractor franchise. Another complementary line of business is to promote the supply of machinery for urban areas, mainly for use in real estate developments (leveling, earthmoving, roads, etc.) and green areas. The company believes that these customers could mitigate the decline in demand during periods with no agricultural work, which are subject to specific time windows.

IncluirTec

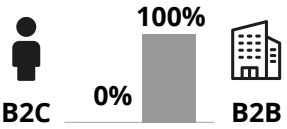
Origin: Colombia

Foundation year: 2016

Value proposition: to generate an alternative risk assessment that facilitates the credit process for financial institutions, in order to improve credit access for small and micro agricultural and livestock producers.

Operations in other countries (mainly):
Mexico. Honduras.

Business model:



Users / Clients: 18

Revenue (USD): 250,000

External financing (USD): 510,000

Direct employments: 24

Barriers:
- Digital transformation of financial institutions.
- Development of local entrepreneurial ecosystems.

Prospects:
- To establish itself as the main financial inclusion tool in Latin America.

Users, jobs, revenue: estimated 2022. Capital received: estimated since 2016.

Lack of access to credit is a problem in Latin America, where only 25% of the 123 million rural producers have access to formal financing and 6% of financial institutions operating in the region have lines of credit for this sector. IncluirTec is a Colombian startup at the intersection between the Agtech and Fintech worlds, and its purpose is to link formal financial institutions (e.g., banks, microcredit organizations, etc.) with small-scale producers. In this context, the need arises to develop a technology that generates an alternative risk assessment, enabling microfinance entities, banking institutions, and non-banking organizations (such as NGOs) to provide credit to rural producers in a fully digital manner, while aligning with their productive capacities and the economic context.

The solution developed is based on a mobile application that allows credit advisors from financial institutions to go to the field and gather information about the applicant. The application allows information to be uploaded in a way that adapts to the production schemes of small and micro rural producers (which tend to include more than one productive activity[7]), using open market information (e.g., raw material prices, input values, among others) and allowing the geolocation of farms.[8] Based on specialized algorithms, the application generates an opinion on credit risk and the optimal conditions for granting credit (such as the ideal times of the year for collection). The platform creates profiles of producers and geographic regions (e.g., departments, costs, municipalities, etc.) in order to provide financial institutions with highly accurate information on the production cycles (e.g., soil preparation, inputs, labor, etc.) of the different areas. At the same time, the application allows the generation of expected production values -using for this purpose, for example, the producer's level of technification, as well as other elements of

7 This may include the combination of various agricultural activities as well as others that are not directly linked to the sector, such as work for third parties, commercial sales, livestock activities, etc.

8. Since many rural farms do not have a specific address, financial institutions often produce hand-drawn directions to the farm, which can be inaccurate.

his production profile-, which is adjusted by estimated sales prices in such a way that the future payment capacity can be foreseen.

IncluirTec does not grant loans directly, but is based on a software as a service business model, aimed at entities interested in providing financing to rural actors. The B2B business model is based on charging for the initial installation of the platform, plus an annual subscription fee associated with the maintenance and updating of the operating system. In addition, IncluirTec receives a payment per credit application processed on the platform, regardless of whether it is accepted or rejected.

The application can operate not only online, but also in regions where there is no internet connectivity. In the latter case, once the loan officer is in an area with connectivity, the application transfers the collected data.

Direct users of the services are credit institutions: banks, microcredit institutions, NGO's, etc. The loan officers of these institutions use IncluirTec's digital platform to register relevant information and the application's algorithms generate the credit opinion and the optimal conditions for granting the loan. These services allowed credit institutions to reduce the time required to disburse a loan from 25 to 5 days maximum; it should be noted that there are cases in which loans are granted on the same day or the following day. Similarly, it avoids displacing loan applicants to branch offices in urban areas, as it is now the institutions' loan officers who go to rural areas. This also allows the loan officer to geolocate the farm and collect visual evidence of production conditions, as well as available equipment (such as tractors, work implements, irrigation systems, etc.). IncluirTec makes it possible to offer loans with adjusted conditions and thus drastically reduce delinquency (currently equivalent to only 3% of the loans granted through this platform).

Almost 40% of loans granted using IncluirTec's platform were targeted at rural women. The company has already succeeded in globalizing its operations with clients in Mexico and Honduras, as well as Colombia. The platform is used by eighteen financing institutions (bank and non-bank) in the three countries mentioned above, with more than 800 loan officers using it in their day-to-day operations.

By 2026, the goal is to consolidate its leadership in Colombia, Mexico, Peru and Central American countries, which together have 1,086 agricultural financing institutions. This goal will also consist of having eighty consolidated clients in those countries, which could have an impact on three million small and micro rural growers.

Biofeeder

bioFeeder

Origin: Ecuador

Foundation year: 2016

Value proposition: automate shrimp production feeding systems by increasing efficiency through cost reduction and mitigating environmental impact.

Operations in other countries (mainly):
Mexico. Colombia

External financing (USD):
4,300,000

Business model:
B2C 100% 0% B2B

Users / Clients:
150

Revenue (USD):
13.000.000

Direct employments:
100

Barriers:
- Customers: lack of financing for equipment.
- Institutional links for technological development.

Prospects:
- Increase the number of local clients and countries of the region.
- Developing financing for small growers.

Users, jobs, revenue: estimated 2022. Capital received: estimated since 2016.

Biofeeder is an Ecuadorian startup company with the objective of automating feeding systems for shrimp farming. The system developed by the company includes hardware and software and is based, broadly speaking, on a hydrophone[9] that captures the sound generated by the shrimp chewing the balanced feed and on a set of algorithms that are fed by artificial intelligence (AI) systems, so as to identify through the sound the amount of feed available in the water. Based on this process, Biofeeder equipment adjusts the amount of feed automatically according to the production strategy, without the intervention of operators. This autonomous equipment, which significantly improves profitability, replaces other methods of manual feeding or feeding at preset times. Moreover, the feeding system has solar panels, making it self-sustainable in terms of energy consumption.

Automation of the shrimp feeding system has three impacts on the production process: (i) accelerated shrimp growth rate; (ii) reduced conversion rate, with a lower amount of feed per gram of weight gained; and (iii) reduced mortality, since, by generating less waste, the soil can remain in better environmental conditions, which favors shrimp farming (in addition to mitigating environmental impact[10]). These improvements in technical indicators increase the profit margin of the activity, which can triple. The company also offers its clients integrated production management software, where producers can know in real time the state of shrimp feeding, estimate the approximate weight gain on a daily basis, know the cost per hectare and monitor the correct functioning of the equipment. The software is supplied by algorithms that, in addition to forecasting the future weight of the harvest, help the producer to choose optimal harvesting time, seeking to maximize profitability. Once the strategy has been defined, the software not only monitors progress, but also dynamically adjusts the variables to achieve the planned objective.

9 A hydrophone operates as a "microphone" that can be used underwater. Technically, it operates as a sound-to-electricity transducer that has the ability to be used in water or other liquid.

10 Since the water used for shrimp farming is then discharged into rivers, achieving a production process that generates less waste improves its quality and reduces contamination.

Its in-house designed and developed feeding system includes the mechanical feeder, the electronic card, the software used to control and supervise the processes carried out by the various devices remotely, the production management software and the AI-based algorithms for the generation of production instructions. In addition, the company provides maintenance and customer support services. The business model is based on a platform as a service, in which the client pays a monthly fee for contracting the feeding services, without the need to purchase the equipment, a strategy that enabled the company to become a comprehensive shrimp feeding services provider, rather than an industrial

equipment sales company.

Biofeeder equipment is aimed at large, medium and small shrimp producers.[11] Typically, one unit per hectare is used, depending on average density, which feeds between 100 and 200 thousand shrimp. In Ecuador, there are 240,000 hectares for shrimp aquaculture, but only 80,000 have automatic feeding, thus there is significant room for growth at the local level. Other countries with large volumes of shrimp farming are Mexico and Peru, as well as other Central American countries. Regionally, the use of automatic feeding equipment covers only 20% of the total area.

In 2022, the company started its first operations in Peru, Mexico, Panama, El Salvador and Costa Rica. The process of becoming international was accompanied by Claro, which took advantage of its presence in the aforementioned countries to facilitate Biofeeder's entry into the market. The company is currently developing an alternative system to measure the amount of excess feed that collects at the bottom of shrimp farming pools. It is planned to offer a complete package that includes both equipment and feed (for which they should establish links with input producers) and, in turn, charge for the services once the harvest has been completed. Biofeeder would thus help small producers to make use of their equipment without the need to go through financial stress. To implement this strategy, Biofeeder is looking to partner with packing plants, where shrimp is packaged for commercial sale.

11 A large shrimp producer can have up to 15,000 productive hectares, while in the case of smaller-scale producers, the area is usually less than 100 hectares.

Bio Natural Solutions

Origin: Peru

Foundation year: 2017

Value proposition: optimize organic waste and food loss management to improve the quality of life of consumers in an environmentally sustainable manner.

Operations in other countries (mainly):
Guatemala. Colombia

External financing (USD):
1,125,530

Business model:
B2C 0% 100% B2B

Users / Clients:
31

Revenue (USD):
390,000

Direct employments:
24

Barriers:
- Competition.
- Regulatory aspects.
- Financing for R&D.

Prospects:
- Expand the market for high value-added products.
- Diversify into other LATAM countries.

Users, jobs, revenue: estimated 2022. Capital received: estimated since 2016.

Local markets, generally less organized than export-oriented production, experience post-harvest losses that can reach up to 60%. Therefore, the adoption of good practices to reduce waste levels is crucial. Bio Natural Solutions (BNS) is a Peruvian biotechnology company that offers environmentally sustainable solutions for reusing organic waste and reducing food losses through innovation.

Products developed by BNS are generated from the reuse of fruit peels such as avocado, mandarin oranges and mango, and waste from the frozen food industry. Through treatment with antioxidants (molecules with antimicrobial capacity), the company markets two groups of solutions: (i) waxes and fungicides, used as organic coatings for post-harvest treatment of fruit, which can double their shelf life. This segment accounts for approximately 90% of sales and is mainly demanded by fruit exporters; it is used for mango, avocado, and citrus (coatings for blueberries and grapes are currently under development); and (ii) organic disinfectants, as a replacement for chlorine and other chemicals. Products are certified organic by the main global standards.

Carbon footprint measurements are a complementary service, carried out through annual studies. The company is currently working with Brunel University on measurements of the impact of poor waste disposal in landfills to quantify, among other things, greenhouse gas emissions. Such studies are in demand by fruit importers as a customer loyalty tool. BNS also carries out training and technology transfer initiatives for small farmers.

Innovation is an essential component, reflected in the establishment of the Smart & Sustainable Foods (SSF) Innovation Center as a core component of the company. The Center serves as a channel for researchers and scientists within the company and affiliated researchers from around the world, enabling synergies and collaborative projects to take place. Each year, 20% of net income is invested in R&D.

Active customers comprise 31 companies, including regular product purchasers. The foreign market is of great importance to BNS in terms of turnover, with exports accounting for around 45% of sales and

a projection of 60% by 2023. The company currently has representatives in Guatemala and Mexico, and sanitary approval for its products is in progress in other countries, such as Argentina, Uruguay, Chile, Brazil, and the Dominican Republic. The company is also focused on growing products for high- value crops, such as blueberries and other berries.

In conclusion, Agtechs worldwide have a promising future, and those in Latin America are no exception. Within this region, Andean Agtechs have a growing potential to provide technological solutions that position the agricultural sector at the forefront in terms of productivity, connectivity, efficiency, effectiveness, and outreach. However, there are pending tasks to expedite their operations and accelerate their impact. Firstly, the level of maturity of the local entrepreneurial ecosystem must increase, including avenues for financing such businesses, while efforts are made to expand digital infrastructure and connectivity, especially in rural areas. The employment potential that Agtechs can generate is limited by the lack of digital skills, stemming from the rural producers' distrust in new technological solutions. Additionally, regulatory aspects focused on swift product approval, along with the promotion of research and development, are essential to drive these ventures forward. Success stories exist throughout the Andean region, from which valuable lessons can be gleaned for fledgling enterprises. Cases outside the Andean region can also serve as guides for scaling certain types of ventures.

Andean Agtechs have a growing potential to provide technological solutions to position the agricultural sector at the forefront in terms of productivity, connectivity, efficiency, effectiveness and reach. However, there are still pending tasks to streamline their actions and accelerate their impact.

8.4 Annex

The survey of Agtech companies in Colombia, Peru, Ecuador, Bolivia and Venezuela was conducted by consulting specialized websites, based on an initial list of companies generated by IICA with the participants in Digital Agriculture Week 2022. Each company was defined by country of origin, sector or main focus of the solution, a brief description of the solution or product offered, contact details, year of establishment, founders and investments received. The last characterization fields in particular are subject to availability of information.[12] Subsequently, IICA-related entrepreneurs in the region and technical staff from IICA offices in the countries of the region[13] were consulted, with whom the preliminary list was reviewed in detail to: (i) identify relevant Agtechs that had not been mapped and (ii) rule out ventures that could not be classified as Agtechs or that were no longer available.

While most of the ventures identified as a result of the search process fall within the definition of Agtech as described above, with a focus on the use of digital technologies, the final list is also composed of companies with other types of technology. Considering the objective of the study, it was considered relevant to keep these projects within the survey, given the potential contribution they can make in terms of innovation.

In line with the methodology used, it should be clarified that the survey is not necessarily exhaustive in terms of the total number of Agtech companies in each country. On the contrary, the section focuses on identifying possible case studies that have reached a certain level of coverage according to the type of companies, solutions offered, main sector of operation, trajectory and projections. Thus, the proposed list could be complemented with additional cases to be reviewed.

After mapping of Agtech ventures was completed, the process of selecting case studies began. An evaluation was made of the potential impact on: (i) the sustainable development of agricultural and food systems and current scope, and (ii) the projection of the venture. Each venture was evaluated, according to the following parameters:

Economic axis:

- **Relevance in the market:** based on the development level of both the company and the technology, the current and potential participation of Agtech was evaluated, seeking to determine the degree of coverage or penetration that it could achieve.

- **Expected economic benefit (micro and macro users):** degree of economic impact that the technology could generate in terms of increased productivity, higher production, quality improvements, input savings, etc., with both a micro valuation (company or producer level) and sectoral valuation (macro impact on the sector).

12 Data on year of start-up, founders and investments received were obtained mainly from https://www.crunchbase.com/. The lack of data on investments may be mainly due to the lack of registration by the aforementioned site or to the absence of external financing of the projects.

13 For more information, see https://repositorio.iica.int/handle/11324/20756

Social axis:

- **Inclusion of stakeholders:** degree of relevance in terms of opportunities offered by technology for the productive, commercial, technical and/or gender integration of different stakeholders in agricultural chains, especially farmers.

- **Contribution to employment:** impact of technology on the generation of new jobs resulting from the development of a product, sector or region.

Environmental axis:

- **Environmental impact:** contribution of technology to reduce impacts on the environment, increasing input use efficiency, contributing to biodiversity conservation and climate change mitigation, as well as soil and water conservation, etc.

Evaluating these aspects for each Agtech, based on a simple quantitative scale,[14] allowed for the initial ranking of the 95 ventures, which served as the basis for selecting the case studies. Additional criteria included type of technology used, country of origin, sector or chain of application and the problem that the solution aimed at solving. The possibility of covering the greatest possible diversity in these additional criteria (i.e., having at least one case of each variant) was a determining factor in selecting the cases on the basis of the ranking mentioned above. Thus, eight case studies from the Andean region were selected, to which two companies originating in Argentina and Brazil, but with operations in the region, were added. These two companies also represent mature experiences, highly established internationally in the LA region and with relevant links to other stakeholders in the entrepreneurial ecosystem, for which reason their inclusion was considered, taking into account the lessons sought in this study.

14 Each variable was evaluated on a scale between 1 and 3, according to a low or minimum/high or outstanding contribution.

9. CONCLUSIONS

The Andean region holds the exceptional opportunity to turn agriculture, an ancient and deeply ingrained sector strongly associated with the identity of Andean countries, into an engine for productive transformation, socioeconomic development, and inclusive and sustainable growth. The Andean countries are characterized by a relatively diversified agricultural structure, where extensive annual crops, multiannual crops and livestock activities coexist. The sector's significance is evident in a wide range of dimensions, ranging from its relevance in the agricultural productive framework, the economic and social context, the generation of employment and the environmental dimension, to its impact on food security. In addition, the recent impact of the C0VID-19 pandemic demonstrated the sector's capacity to counteract abrupt declines in economic growth and buffer social gaps, since agriculture was one of the few sectors that remained resilient and grew in 2020, when the rest of the productive sectors exhibited significant contractions.

One of the first conclusions of this publication worth highlighting is that agriculture is emerging as a sector of opportunities in the Andean region in the new post-pandemic normality, in the context of growing commitments related to decarbonization, and in the face of pressing challenges such as climate change. However, in order to enhance its development and transformation potential, it is essential to address the various long-standing challenges, such as those related to its low productivity, as well as those relatively more recent but equally pressing, such as climate change, in order to transform them into opportunities. In order to achieve this, shortcomings in various areas, such as infrastructure and institutions, must be addressed; new strategies in areas such as climate change and gender must be redesigned; and new market niches, where the Andean countries have comparative advantages, must be tapped.

The sector is currently facing a vulnerable situation for farmers in the Andean region due to various factors, such as a deficient and low-density road network, as well as limited access to electricity and irrigation in rural areas. Closing basic infrastructure gaps for agricultural production is another important conclusion that is necessary to boost the productivity of the agricultural sector. Obviously, given the high costs associated with closing these gaps, it is important to consider local realities and non- traditional projects that are increasingly common in the region, as in the case of wind and photovoltaic energy. Investing in closing these gaps at the most granular level possible, i.e., at the farm level, would have a significant, direct and positive impact on the productivity of the agricultural sector by increasing its technical efficiency and agricultural profitability. Estimates presented here indicate that the costs of road provision, energy access and irrigation on Andean farms vary by country and type of "solution"; however, in all cases, they prove to be win-win strategies. In some cases, the cost-benefit calculations show a level of profitability close to 300%, as in the case of the investment in electric power in Bolivia. One of the main conclusions is that, given that the benefits exceed the costs, investing in productive infrastructure in the agricultural sector represents an invaluable strategy for increasing the technical efficiency of the sector and its competitiveness, along with improvements in the quality of life of those engaged in agriculture, better working conditions on farms, better access to and quality of services, products and technologies, all of which translate into higher productivity.

Another conclusion of this study is that it is imperative for sustainable, inclusive, and viable agricultural and livestock development to have an efficient institutional framework characterized by optimal public-

public coordination and collaboration. This is essential to effectively address the various bottlenecks affecting this sector. While the institutional framework of each Andean country has its own characteristics, a vertical structure that tends to operate in silos predominates in all of them. In terms of institutional strengthening, the main areas of opportunity that have been identified include the optimization and prioritization of the provision of basic public goods that farmers need to join agro-industrial export value chains (e.g., animal and plant health and food safety requirements, certifications, agricultural infrastructure, etc.). A further important aspect is to improve the formulation of short-, medium- and long-term sectoral agricultural policies that promote productive development with strategic definitions and guidelines. For policies to be inclusive, they must focus effectively on small and medium-scale farmers, adapting to the countries'

realities, local needs and heterogeneity, and offering a diverse range of support mechanisms. In order to be sustainable, policies must include better adaptation and resilience to climate change and a clear focus on mitigating the harmful effects of the sector on the environment.

To enhance the potential of Andean agriculture, its development and transformation, it is crucial to address the various long-standing challenges by closing gaps in infrastructure and institutions; redefining new climate change and gender strategies; and taking advantage of new market niches where Andean countries have competitive advantages.

The main recommendations for institutional strengthening of the agroindustrial sector in the Andean countries include improving coordination, prioritizing and focusing efforts on the most strategic areas such as health and safety services, which have a direct impact on productivity and competitiveness. It is also suggested that efforts be focused on boosting agricultural productivity through targeted and coordinated strategic plans for productive development, including infrastructure, research, innovation and technology transfer, as well as improved road, port and air connectivity. The institutional framework should also promote the competitiveness of the sector's production chains, taking advantage of the geography and climatic characteristics of the Andean agricultural sector. An interesting example of how the institutional framework supported the dynamism of the agricultural export sector is the case of Peru, where sectoral policies to promote irrigation, phytosanitary and animal health measures and trade liberalization, among others, led to a successful competitive insertion in international markets.

Available projections predict significant temperature increases between 1°C and 4°C by 2050, the tropical zone of South America being one of the most threatened. Various indicators of climate vulnerability show that the Andean countries have a medium to high level of vulnerability due, on the one hand, to geographical and social characteristics that have an impact on agriculture, and on the other hand, to their low or non-existent preparation for adverse climatic effects. Since agriculture in Andean countries is very sensitive to changes in temperature and precipitation, impacts on productivity, trade and essential crops are expected, exacerbating their exposure to food insecurity. Furthermore, climate change effects impose high levels of risk in terms of agricultural production, human impact, economic losses, significant losses in agricultural production and food security, affecting essential crops such as rice, beans, wheat, corn, soybeans, bananas, coffee and sugar cane. Likewise, populations whose incomes depend directly on agriculture, such as indigenous groups that depend on this activity for their livelihoods, are among the most vulnerable to climate change impacts.

Another relevant conclusion of this report is that this threat implies a sense of urgency that should dramatically change the priorities and timelines for action in the Andean countries. Therefore, it stresses the importance of taking prompt action to mitigate climate change because the longer the delay the higher the economic and social costs will be. Climate change adaptation actions vary from country to country. In the context of Nationally Determined

Contributions (NDCs), agriculture is one of the prioritized mitigation areas for the four countries of the Andean Community of Nations (CAN). In fact, agriculture can play a key role in addressing climate change since, together with forestry and land-use change, it is responsible for about 25% of global GHG emissions. Key recommendations include crop diversification, the use of improved varieties and intercropping, forest, soil and water management, development of agricultural research and improved water use efficiency, agro-climatic and market information services, monitoring of mitigation and adaptation goals, impact and resilient crop assessment, the strengthening of agro-climatic information services and market intelligence.

The treat of climate change brings with it a sense of urgency and prompts reflection on the importance of taking early action to mitigate its high economic and social costs.

Regarding gender issues, it is concluded that while women's autonomy and economic empowerment has been on the international and regional development agenda as a priority issue for years, the prevailing situation is still disadvantageous for women in Andean countries, and this is no exception in the agricultural and livestock sector. As evidenced by available indicators, there are significant restrictions and vulnerabilities for the female population engaged in agricultural activities or residing in rural areas of the Andean countries in terms of their economic autonomy and lack of opportunities. This is manifested in various dimensions, including high illiteracy rates, traditional social roles and persistent cultural gender biases that limit women's economic autonomy, traditional forms of access to land tenure with mechanisms that privilege men, a wage gap between men and women (in the agricultural sector, women receive only half of what men receive), and the incidence of gender-based violence which tends to be relatively high in rural areas. This is in addition to a growing phenomenon of feminization of poverty, observed in households headed by women, which in turn exacerbates their work overload compared to that of men. This gap is even greater in rural areas, where women invest a high percentage of their time in unpaid domestic activities, which perpetuates their precarious labor situation due to the strenuous hours of work they perform and their inability to save, making them highly vulnerable economically.

Another conclusion to be drawn regarding gender in agriculture is that women's participation and empowerment represent an area with great potential for developing agriculture hand in hand with quality employment and closing gender gaps and inequalities in the countries of the Andean region. To achieve this, one of the recommendations is to foster autonomy through actions that prioritize the promotion of basic and technical education to provide women with certifiable skills and competencies, thus enhancing their opportunities for quality, decent and productive employment; strengthening women's associative networks and their capacity to access productive resources, including financial services and marketing channels for the commercialization of goods and services. Simultaneously, it is recommended that the institutional framework focus on strengthening the development of public policies, normative and regulatory frameworks, establishing accountability links at the decentralized level, geared

towards empowering, consolidating and broadening the scope of local governments and their institutional capacities.

Another powerful conclusion of this report is that there is an exceptional opportunity to diversify and position the agricultural supply of the Andean countries, strategically positioning the sector in various market niches that are already competing in international markets. Opportunities must be created to promote Andean agriculture in a strategic, inclusive and sustainable manner for the benefit of their economies and the well-being of their populations. In turn, this can be accomplished by generating a positive socioeconomic impact in a variety of areas: from job creation and income generation for indigenous and peasant communities to the development of the different segments of the production chain, while promoting productivity in harmony with the environment.

There is an exceptional opportunity to diversify and position agricultural supply internationally in several niche markets where the Andean countries have competitive advantages.

One such niche is that of Andean superfoods, which the countries of the region produce and export, through the combination of their competitive advantages derived from natural conditions and geography with a growing global demand for healthy foods with intrinsic nutritional characteristics that imply sustainable and environmentally friendly consumption and have a positive impact on the producers' quality of life. In fact, the benefits of these superfoods extend beyond their nutritional qualities, since, in many cases, they have ecological attributes and productive benefits that allow for the conservation of forests and the Amazon. Many of the challenges are well-known from the past, such as the lack of adequate financial sources, instruments and formal mechanisms for small-scale producers to cover their financial needs; the lack of technological adoption and technification; poor access to training and technical assistance to increase production and productivity; and a limited provision of basic public services, including energy, irrigation, roads, etc. There are other relatively more recent challenges, which have to do with market factors, such as increased global competition and the need to access and compete in these markets through new mechanisms, such as certifications and a production chain traceability system. Success stories highlight the importance of product quality, as well as offering consumers value-added and differentiated products, based on a system of production traceability and attributes (through green or environmental certifications, and/or designation of origin, a sustainability and socio-biodiversity mark, agricultural production, fair trade, environmentally sustainable production, among others). Furthermore, a fundamental success factor involves developing key linkages and effective synergies, diversifying supply with derivatives and leveraging the potential to enter new industries beyond the food industry, such as pharmaceuticals, agro-tourism, cosmetics, nutraceuticals, to mention the most important ones.

Given the natural wealth of the Andean-Amazon countries in terms of flora and fauna diversity, another niche that should be exploited is forestry, through the sustainable management of natural forests and forest plantations, timber forest products (TFPs) and non-timber forest products (NTFPs) in the region and by developing productive activities to improve the livelihoods of the local population. To date, this sector has been underutilized and has marginally contributed to the national economy, employment, ecosystem management and improving the livelihoods of the population. To further its development, it is essential to continue promoting the various timber and non-timber value chains in all the countries of the Andean region, develop new forest products and ways of adding value that will enable forest products to be positioned as "niche products", and open up markets by taking advantage of new trends. Successful

cases of management of natural and planted forests in tropical and Andean areas have not experienced continuity in terms of institutional, legal, technical, and financial aspects. Lessons learned point to the need to revitalize the forestry sector by establishing new governance at the policy level, as well as laws and institutions based on a philosophy of forest development, promotion and conservation compatible with forest use, reforestation and the development of the forestry industry. It is also essential to address the sector's main challenges, including increasing deforestation due to the expansion of pastures and croplands, issues of legal security over forest areas, lagging technification and processing throughout the forest chain, the high incidence of illegality in timber forestry, unfinished agrarian reform, obsolete institutional and legal frameworks, high transaction costs in the forestry sector, and the lack of availability of data and information for decision making, to mention a few challenges.

Lastly, a final niche addressed in this publication is that of Agtechs, which are new business models that use innovative technologies such as big data, artificial intelligence, Internet of Things (IoT), blockchain, Smart farming, Fintech, among others, to improve the efficiency and performance of agricultural processes along agrifood value chains, increasing their efficiency, productivity and sustainability, and mitigating their environmental impact. In some cases, they are even contributing to the development of new products, such as bioenergy, biomaterial products and new foods. Ninety-five Agtech ventures have been identified in the region, which are offering services on various links of the value chain, most of which are in Colombia and Peru, followed by Ecuador, Bolivia and, finally, Venezuela. The main challenges faced by Andean Agtechs for their growth, replicability and consolidation include low maturity of the local entrepreneurial ecosystem, lack of digital infrastructure and connectivity in rural areas, lack of digital skills and personnel with the required skills, distrust of new digital-based technologies, limited access to financing for entrepreneurs and for research and development, and hindering regulatory aspects. The common aspects of the success stories of Andean Agtechs illustrate that the local entrepreneurial ecosystem plays a crucial role in facilitating their emergence.

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