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Tapping the Potential of Bolivia's Agriculture and Food Systems

to Support Inclusive and Sustainable Growth

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June 2019

Agriculture Global Practice

World Bank Group

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1818 H Street NW, Washington DC 20433
Telephone 202-473-1000; Internet: www.worldbank.org

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Cover design: Kilka diseño gráfico.

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Acknowledgments

This report was prepared by a team that included Luz Diaz (Task Team Leader), Pablo Valdivia, Michael Morris, Julia Navarro, Viviana Perego, Ashwini Sebastian, and Albaro Tutasig (all of the World Bank). External contributors included Maria del Mar Polo (FAO), as well as John Horton, Jorge Caballero, Milagros Chiappe, Gerardo Mandieta, and Sandra Lazarte (all Consultants). The team is especially grateful to Ricardo Fort and Mauricio Espinoza (Grupo de Análisis para el Desarrollo – GRADE), authors of the productivity analysis presented in Chapter 4 of this report.

Steven Jaffee, Robert Townsend, Juan Gonzalo Flores, and Francisco Obreque served as peer reviewers. Preeti Ahuja, Alberto Rodriguez, Indu John-Abraham, and Oliver Braedt supported the study and ensured that resources were available for its implementation.

Executive Summary

Agriculture and the rural space will continue to demand the attention of policy makers in Bolivia for several reasons, even as urbanization gains momentum. First, agriculture is a proven engine of economic growth. Aside from showing its strength in decades past, in recent years agriculture shielded the Bolivian economy from the worst effects of the decline in other primary sectors, and in the future, healthy rates of agricultural growth will make the overall economy more diversified and more resilient. Second, a robust and dynamic agricultural sector will continue to curb dependence on the mining and gas sectors, while contributing significantly to inclusive growth, value addition, the creation of more and better jobs on and off of the farm, and better nutrition for all. Third, because agricultural growth in Bolivia has proven to be pro-poor, maintaining that growth is essential for continued reductions in poverty. Fourth, because climate and other shocks affecting agriculture can significantly disrupt steady gains in economic growth, poverty reduction, and food security, building a resilient agricultural sector is critical to sustain those gains. Finally, although policy makers will want to support agricultural growth, they will not want that growth to compromise the future for generations of Bolivians by squandering and degrading irreplaceable natural resources.

Pattern of agricultural growth in Bolivia

Bolivia has used its diverse natural capital to grow agriculture and generate wealth. The share of agriculture in total GDP remains substantial at around 11–12 percent, although it has declined in tandem with Bolivia's economic transition. Since 2000, the value generated by the agricultural sector has grown at a steady rate of 3 percent annually, with particularly dynamic growth (at about 4.9 percent) since 2013. At the same time, agriculture has contributed to Bolivia's tremendous gains in poverty reduction.

As in other countries in the region, in Bolivia the pattern of agricultural growth has been highly influenced by urbanization, income improvements, and changing diets. Agricultural value is concentrated near the largest urban centers: 72 percent of total agricultural value added is concentrated in Santa Cruz, Cochabamba, and La Paz Departments.

Agricultural growth in Bolivia has largely been based on the expansion of agricultural area, accompanied by input intensification. A comparison of population growth in Bolivia between 1950 and 2017 with the expansion in agricultural area that occurred

over the same period shows that the country has added 0.34 hectares per inhabitant. Land expansion differs markedly in scope across regions. Between 1950 and 2016, total harvested area increased fivefold in Bolivia, rising from around 654,000 hectares to more than 3.5 million hectares. Most of this expansion (73.6 percent) took place in the Lowlands and Amazon Regions, considerably surpassing the expansion of harvested area in the Highlands (14.6 percent) and Sub-Andean Region (11.8 percent). Santa Cruz Department in the Lowlands Region had 8.9 percent of all harvested area in 1950 and 60.7 percent by 2013.

A parallel and extremely important trend is the continuing division and fragmentation of agricultural land in the Highlands, Amazon, and Sub-Andean Regions, where average farm size does not exceed 3 hectares. Land fragmentation is most acute in the Highlands, where 60 percent of all farms are now smaller than 1 hectare.

In today's Bolivia, approximately 45 percent of the harvested area is linked to the production of industrial commodities (particularly soybeans) to satisfy local and export demand, particularly demand from the animal feed industry (due to the increasing consumption of animal protein) and increasing domestic demand for biofuels. When cereals are included, this figure increases to 80 percent. The expansion of land for agricultural commodities is linked to large scale foreign investment (mainly from Brazil) and it is part of a broader trend observed in South American countries. In fact, during the period 2006–16, the land expansion for soybean production in Bolivia has been modest in comparison with the expansion experienced in countries such as Paraguay and Uruguay. In the latter, about 840,000 hectares of soybean production were added during the period 2006-2016, nearly 2.5 times the expansion experienced in Bolivia.

In the face of macro-economic constraints and changing trade conditions in key agricultural export markets, the agricultural sector faces the important challenges of sustaining future growth and ensuring that the gains from that growth translate into stronger economic inclusion and environmental sustainability. For example, despite significant gains in poverty reduction, the average income of the population under the poverty line—the majority of whom depend on agriculture—needs to increase by 75 percent to lift them above poverty. Furthermore, the continuation of current patterns of agricultural growth, which are based on land expansion and increased use of inputs, are not enough to sustain long-term productivity gains. They are also likely to severely compromise the future provision of key ecosystem services and will exacerbate climate-related challenges.

Insights into agricultural productivity

Sustained gains in productivity, driven by technological change, technical efficiency, and managerial capacity, have been modest in Bolivia, although signs of improvement are emerging. Total Factor Productivity (TFP) growth was negative during 2001–10 but was estimated at 2.6 percent during 2011–15. At the same time, the macro-regions of Bolivia exhibit substantial differences in the kinds of production systems they can support, the characteristics of producers, and yields of the main crops. Considering these marked differences, more granular information on productivity and levels of technical efficiency across and within macro-regions, crops, and farms of different sizes could provide greater insight into new sources of productivity growth in Bolivian agriculture. This report attempts to provide such information. Although data constraints preclude the analysis of differences in TFP growth across macro-regions, results of a stochastic frontier analysis and meta-frontier estimates, which measure technical efficiency, highlight important gaps across and within the four macro-regions (Box 0).

The fact that TFP cannot be estimated separately for each macro-region is unfortunate. Filling this knowledge gap would help to explain the dramatically low

Box 0. Enhancing productive efficiency across Bolivia's macro-regions

Results of the Stochastic Frontier Analysis (SFA) conducted for this report indicate that investments that could effectively increase technical efficiency and bring less-efficient farmers close to the regional frontier include support for collective action, credit programs, mobile phones, and irrigation. The efficacy of each type of investment varies by macro-region. For example, collective action is important for reducing technical inefficiency in areas where land holdings are highly fragmented (the Highlands and Sub-Andean Regions). Programs and projects that foster collective action are more likely to improve the income of peasant families than programs that target individuals. On the other hand, improving access to credit is more likely to be an effective investment in regions with better market integration and more financial institutions (the Lowlands and Sub-Andean Regions). In the Highlands Region, where access to mobile phones and landlines is still limited, better diffusion of mobile phone technology would enable information on agricultural technology and markets to reach large numbers of producers who otherwise have very sporadic and limited access to such information. Across all four macro-regions, investments to improve access to irrigation seem likely to be effective in reducing technical inefficiency. Irrigation would enable producers to control and intensify their use of water to improve productivity and reduce uncertainty in agricultural production cycles.

Although the analysis of technical efficiency across the macro-regions provides a general idea of measures that could improve productivity in each region, a more targeted meta-frontier efficiency (MFE) analysis focusing on particular crops and farm-size groups helps to refine those alternatives for different regions and groups of producers. For example, the analysis shows that the technical efficiency of soybean production is higher on larger farms compared to smaller ones in the Lowlands Region, probably as a result of economies of scale. In the case of potato, small-scale potato producers were found to be less efficient in the Highlands Region but not in the Sub-Andean Region. In the case of rice, the MFE found no significant differences in the efficiency of rice producers in different farm-size groups, and no differences in the technology gap.

The observed differences in the technology gap and dispersion in the levels of efficiency observed across crops, within and between regions, suggest a range of differentiated strategies to improve productive efficiency. In some cases, the largest benefits would come from expanding the technical production frontier through the adoption of better agricultural technologies. Higher dispersion in efficiency levels suggests a focus on bringing less-efficient producers closer to the technical production frontier through programs that increase collective action, improve production practices, and facilitate access to credit, among others.

level of aggregate labor productivity in Bolivian agriculture reported by some sources, which probably conceals important variations in rural livelihood strategies across Bolivia. For example, in the Highlands, farmers mainly live in nearby urban settings, and agricultural work is highly seasonal, with labor migration occurring at specific periods of the year to supplement agricultural incomes.

Aside from these productivity and efficiency considerations, Bolivian agriculture faces a competitiveness challenge. The fundamental challenge to competitiveness is that Bolivia is a landlocked country, but it is amplified by constraints in institutional capacity and in the enabling environment for overall business dynamism and investment. As discussed below, efforts have been made to address broad competitiveness constraints; at the sectoral level, the focus has been on creating opportunities for small-scale and vulnerable farmers and communities and expanding industrial agricultural production.

Insights on the policy framework to support inclusive sectoral growth

The policy framework that has supported agricultural growth since President Morales came to power emphasizes achieving food self-sufficiency and sovereignty at the national and household levels and redressing historical imbalances and inequalities resulting from previous development models. Therefore, policies and programs have heavily focused on small-scale producers and indigenous communities, especially in more marginalized and vulnerable geographical areas with high levels of poverty.

Revenues from the extractive industries have been redistributed across economic and administrative units, providing resources for developing productive sectors (including agriculture) and related activities. Broad estimates of public expenditure between 2006 and 2016 by economic sector reveal a fivefold increase in the overall size of the executed budget. Public spending on the productive sectors increased steadily, especially from 2010 onward, until peaking at approximately US$1.4 billion in 2015. In 2016, expenditures for productive sectors decreased, despite a continuing increase in overall budget execution.

These investments have been supporting common enablers, such as key infrastructure for connectivity. For example, over the 10 years from 2008 to 2018, the public investment in the primary road network grew by 82 percent, and important efforts were made to improve trade logistics across borders.

In the agricultural sector, the share of agricultural expenditure in total expenditure fell from 9 percent to 6 percent between 2006 and 2008. Between 2008 and 2015, a period of strong fiscal expansion, the share of agriculture in total public expenditure remained constant at around 6 percent, followed by a slight decline in 2016. Agricultural investments have supported key sectoral enablers such as land titling and administration, plant and animal health and food safety, and to a lesser extent research, development, and innovation. An important set of programs emerged to support expansion of irrigation and mechanization and shift the technological frontier outward. Still other investments were channelled through demand-driven programs that directly supported producers and their organizations. For the latter, the amount invested/committed is broadly estimated at US$525–540 million for the period between 2006 and 2022 (excluding important investment programs such as the coca program and investments through the Fondo Indigena). As noted, in line with overall government policy, most of these programs target poor and marginalized producers and communities, often in remote areas with high levels of poverty and vulnerability. Most of the support is for production, typically through one-off transfers of equipment, seed, and inputs.

To ensure food sovereignty, the government has also embraced important trade and price-related policy interventions as a response to price variability in in-

ternational markets. The policy initially consisted of export bans on a set of key products in the mid and late 2000s, and during the present decade it has taken the form of export quotas for key products. The export bans were active for different products at different times; for example, beef exports were prohibited over 2008–12, and exports of other crops have been prohibited intermittently. The negative effects of the beef export ban on production and the limited impact on reducing domestic prices are well documented. Since 2013, the government has adopted a more flexible system of export quotas, with quotas gradually increasing as margins in the domestic market become thinner with increased supply, and as international conditions deteriorated for some products (such as soybeans).

In the most recent policy documents, the government's aspirations for agriculture are reflected in significant proposed production increases, to be attained through (1) an expansion of agricultural land by more than one million hectares between 2016 and 2020 and (2) agricultural intensification brought about by the adoption of irrigation and increased fertilizer use, the latter specifically in commercial agriculture commodities. Strategies also include the creation of domestic demand to drive the expansion in agricultural land (specifically, by stimulating demand for biodiesel crops through an ethanol mandate requiring gasoline to be blended with at least 10 percent ethanol beginning in 2018 and at least 25 percent by 2025). An interesting development is the aspirations surrounding the diversification and expansion of agriculture and food exports.

Insights into opportunities and effective strategies for inclusive and sustainable agricultural growth in Bolivia

Agricultural growth opportunities in Bolivia—Given the large number of producers involved in supplying domestic food markets, a continued priority in Bolivia is to enhance opportunities for creating wealth around domestic value chains. The size of these opportunities will largely be linked to domestic consumption and market developments. Consequently, a first and very important source of future agricultural growth is linked to growing food demand resulting from urban population growth, which is projected to average 1.9 percent annually through 2030.

A second source is linked to changing diets and consumer preferences for differentiated and quality products, including increased consumption of vegetables, fruits, legumes, and other products in the high-value spectrum, and further development of quality-differentiated markets through continued formalization of the retail sector, development of the gastronomic industry, and development of demand for fresh and locally produced food (short-value chains/*circuitos cortos*). Increasing demand for agricultural commodities and food in domestic markets will provide opportunities for expanding local production and substituting imports—for example, some fruits and vegetables, which currently account for about 3 percent of total import value. Much of the food imported into Bolivia today consists of processed products, however, and it will be challenging for domestic producers and processors to gain a share of the market for these products in the future. Significant investments by the private sector will be needed to build local processing capacity and overall value chain developments to compete with imports.

A third emerging opportunity is linked to public policies that create domestic demand in non-food sectors, such as demand for biofuels, which is expected to reach 380 million liters in 2025. To fulfill this demand, the area under biofuel crops (mainly sugarcane and soybeans) is expected to reach 400,000 hectares. As a result, the government estimates an increase in agricultural GDP of about 3.9 percent and of total GDP

in about 0.2 percent, with different estimates on the number of jobs generated.[1]

A fourth opportunity will come from enhancing the performance of current non-traditional export value chains, such as cocoa, beans, coffee, quinoa, brazil nuts, and beef, and over the longer term, from creating opportunities for new export products (such as Amazonian products).

Looking to the future, what is our understanding of the successful pursuit of opportunities for sustained, inclusive agricultural growth in Bolivia? The approaches to agricultural development implemented in the past few decades and the patterns of development provide good lessons to inform future strategies. Support to agricultural growth has largely been based on two growth models. One model has focused on large-scale expansion of industrial, commercial agriculture; incentives for private investment have taken the form of preferential trade arrangements with targeted regional markets, policies to facilitate access to land and imported agricultural inputs (including genetically modified seed), and policies that have restricted exports and imports of particular products to ensure national self-sufficiency. The other model has focused on small-scale agriculture, supporting production improvements among mostly poor and vulnerable farmers operating at a self-sufficient level or at some limited level of market integration.

In both instances, drawbacks can be identified. The industrial agricultural expansion model has relied on land expansion and given little attention to securing gains in long-term productivity, inclusiveness, and environmental sustainability. With respect to small-scale agriculture, the approaches have not been sufficiently ambitious in pursuing opportunities for market integration, value addition, and therefore for creating quality jobs.

In the future, a successful sustainable and inclusive agricultural growth strategy in Bolivia would imply targeted strategies to ensure benefits to farmers operating at the subsistence and commercial levels, and to a set of rural and urban actors, more broadly, via job creation opportunities.

Ensuring continued gains for *subsistence producers* who are not integrated into commercial agriculture will require productivity improvements, cost-efficiencies, and the inclusion of nutrition and climate-smart approaches into the development of production systems. Interventions at this level would benefit from close monitoring of developments in production to support (when feasible) a graduated shift from subsistence to market-oriented production. These types of producers in particular will benefit from a combination of strategies to create income opportunities within (on-farm/off-farm) and outside the agricultural sector.

Within the context of *market-oriented production*, the further development and consolidation of opportunities for inclusive and sustainable agricultural growth in Bolivia will require a set of targeted strategies to solidify opportunities in a range of markets (Table 0). In the most traditional production sectors (such as potato production), as well as in diversification into high-value products for domestic markets, success will depend greatly on developing competitive advantages around cost reductions, quality and productivity improvements, efficiencies along the value chain, and market integration, accompanied by improved capacity to manage risks (price fluctuations, climate shocks, pest and disease outbreaks, and so on). These developments have potential to be largely inclusive and to generate gains for a sizeable number of rural producers and laborers in production and, particularly on value-added activities.

1 Ranging from 27,000 jobs created by the additional expansion of sugarcane production on 150,000 hectares to 100,000 jobs generated from the entire area expansion of sugarcane and soybean production.

In *industrial commodity sectors serving domestic and/or export markets* (such as soybeans, sugar, sorghum, and other industrial commodities), success will depend on productivity improvements and cost-reductions (for large-scale and small-scale producers), anchored in significant improvements in environmental and social sustainability and risk management strategies. The potential to generate jobs in these subsectors is not necessarily linked to primary production activities but to associated activities such as logistics, storage, distribution, and domestic processing.[2]

In the case of *non-traditional agricultural exports*, a cost-reduction strategy will help to increase Bolivia's participation in export markets that are not highly sensitive to quality (for example, some market destinations for beef, although sanitary compliance would be critical), but more integrated value chain strategies will be needed to create and enhance opportunities for products differentiated on the basis of quality or some other trait, taking advantage of Bolivia's outstanding agro-diversity. Consolidating gains in non-traditional export sectors has the potential to be inclusive, benefiting large numbers of small- and medium-scale producers and other actors downstream in these value chains, through value-adding activities.

The use of a combination of strategies to pursue opportunities in a range of markets will bring higher returns, but it also has several important requirements. It requires an understanding of market opportunities, an effort to prioritize and focus investments along selected value chains to increase efficiencies and competitiveness, the proper management of risks, and steps to avoid negative social and environmental impacts.

Looking across all subsectors, undoubtedly the greatest opportunities for agricultural growth in Bolivia will come from: (1) using land more efficiently via sustainable intensification and technology adoption, and (2) adding value by developing post-farm stages of selected value chains. An expansion of agricultural area will be part of the agricultural growth equation, but it must be anchored in proper land-use planning and management, including environmental and social considerations.

Priority actions to grow an inclusive and sustainable agricultural sector in Bolivia

The value chains selected for analysis in this report span a range of subsectors, from traditional ones (potatoes) to those oriented to target domestic/export markets (soybeans, coffee, quinoa, beef). The analyses identify a broad range of targeted on-farm and off-farm investments and services that can enhance the performance of each value chain in response to market opportunities. These investments include improved varieties and inputs; the adoption of better production and management practices; improved equipment for production and processing; irrigation investments; market promotion strategies; and coordination platforms, among others. Associated with those investments is an enabling policy and regulatory environment and institutional capacities to create opportunities for sustained long-term agricultural growth. The paragraphs that follow discuss the priority areas identified in this report that require strong attention to consolidate future opportunities for inclusive and sustainable growth across a range of markets.

i) Supporting innovation and technology adoption

Agricultural growth in Bolivia has mainly come from area expansion and, to some extent, input intensification. In the future, Bolivia will need to ensure that in-

2 Industry sources estimate that the oilseed complex contributes between 300,000 and 400,000 jobs, covering activities related to the provision of seeds, other input providers, transporters, processing industries, and so on.

cremental advances in productivity are achieved over time, and that will be possible only through the use of innovations and technology that leads to higher levels of efficiency in the use of production inputs.

As the analysis of productivity efficiency illustrates, efficiency gains will come from pushing the technological frontier outward, particularly in the Sub-Andean and Lowlands Regions, and from increasing producers' knowledge and strengthening their capacity to move them closer to the current production frontier possibilities, particularly in the Highlands and Amazon Regions.[3] To achieve this result, it will be necessary to enhance public and private capabilities for innovation—both "hard" and "soft" capabilities—and for innovation and technology adoption and transfer. "Hard" innovation capabilities are related to research and development, and they include a range of technological opportunities linked to production, post-harvest handling, and processing, as well as opportunities for increasing resource and input use efficiency to protect the natural capital for agriculture (land, water, and biodiversity). Examples of "soft" innovation capabilities include the generation of new inclusive business models (such as value-chain finance and product differentiation, certification, and traceability); strengthening public-private dialogue and collaboration; capabilities for "sanitary diplomacy"; and finding innovative and effective ways and instruments to professionalize producer organizations.

Bolivia's agricultural innovation system requires adequate funding and the alignment of policies over the medium and long term to crowd-in private investment, incentivize knowledge sharing, and enhance the capacities of service providers. The key elements of a successful and effective innovation system are still lacking in Bolivia: institutional autonomy, stable and diversified financing, incentive structures that reward the performance of staff and scientists, programs aligned with clients' needs through public-private partnerships, and strong international R&D linkages. The gains achieved by the government to date with multilateral and bilateral support are at risk, owing to the absence of sustainable funding and strategies to retain key scientists and staff.

In some subsectors (industrial commercial agriculture), the private sector is called to take the lead in bringing innovations and R&D initiatives, while the government can concentrate its efforts on subsectors with less potential for private sector solutions. The role of the private sector in mainstreaming soft and hard innovations in Bolivia's agricultural sector cannot be overstated, but at the same time the private sector must play a more pivotal role as a provider of new sustainable technologies and in developing inclusive business models for technology dissemination and adoption.

Several tools are in the hands of public entities in Bolivia to stimulate private sector innovation and technology adoption and transfer. Examples include establishing public-private partnerships; facilitating technology transfer (for example for genetically modified seed via the development of clear regulatory guidelines); expanding the market share of the private sector for agricultural inputs by reducing restrictions on participation, encouraging competition, and leveling the playing field; and creating incentives for the development of inclusive business models in large-scale commercial agriculture.

ii) Value chain coordination, logistics, and connectivity

An important subset of government programs directly targets poor producers with various types of support. Evaluations of some of these interventions/programs have demonstrated their success in improving pro-

3 Results from the analysis of crops within and across regions suggest a combination of strategies to push the technological frontier outward, including knowledge dissemination and technology adoption.

duction, yield, and household income. As this report shows, the effectiveness of these programs can be increased further, particularly as the government intensifies efforts to develop more market-oriented production. For example, there are opportunities to expand coordination vertically, along the full extent of the value chain, and horizontally, through producer associations and producer networks. To reinforce coordination in value chains, it is a priority to adopt strategies that support and/or enhance the role of farmers and other value chain actors and private players, such as public-private coordinating platforms or innovation platforms that convene a broad set of institutions. Furthermore, efforts to support collective action by producers would benefit from systematic knowledge sharing and initiatives that go beyond individual producer organizations to develop networks of producer organizations that can be effective at the territorial/local level.

Programs providing direct support to producers in Bolivia also represent tremendous opportunities to integrate efforts to build financial literacy, pilot financial innovations, mainstream climate-smart practices, and pilot approaches that incorporate nutritional considerations.

Enhanced coordination among public agencies represents an important avenue for increasing the effectiveness of public support to agriculture. It requires policy makers and program administrators to gain a better understanding of the "big picture" and pursue complementarities across initiatives. Initiatives to promote the development of small-scale agriculture sometimes end up operating in isolation, oblivious to other active programs and projects that offer potential synergies. Another critical area requiring attention from the government is to set up robust and integrated monitoring systems for these co-financing investments.

Along with addressing coordination issues for value chains and institutions, a critical step toward consolidating market opportunities is to enhance logistics and connectivity. For Bolivia, strategic investments in ports, roads, and similar infrastructure are vital to competitiveness. Those investments will have to be accompanied by reductions in other post-harvest logistics costs, particularly those linked to trade procedures, export controls, and sanitary and phytosanitary inspections and certifications.

At the grassroots level, secondary and tertiary rural roads are integral to competitiveness for producers, but building and maintaining roads tends to be very expensive. There is a need to ensure that scarce public resources used for this purpose are directed to areas where they offer the potential to stimulate agricultural growth. Along with roads, other off-farm market infrastructure and logistics systems are needed to match demand and supply, ensure that products meet standards for quality and safety, and reduce post-harvest losses. This enabling infrastructure is particularly critical as the country moves toward greater crop diversification involving more perishable and quality-sensitive products. Exploring partnerships with the private sector to build and maintain key productive and market infrastructure will be critical.

iii) Bringing financial services close to farmers

The productivity analysis indicates that access to finance/credit will help to ensure productivity in the Lowlands and Sub-Andean Regions and could gradually improve opportunities in the Highlands and Amazon Regions. Government regulatory interventions to broaden access to finance for a larger number of farmers are partially undermining credit growth dynamics among medium and small insurance companies, however. Mechanisms that facilitate the establishment of credit histories, support the development of flexible collateral arrangements, and account for seasonality in repayment schedules, among others, can be effective ways of tailoring financial services to

farmers' needs. The many programs providing direct support to producers in Bolivia represent tremendous opportunities to integrate efforts to build financial literacy and pilot financial innovations.

iv) Effective management of risks, including environmental and social risks

Bolivia should be commended for making an effort to develop risk transfer mechanisms to help farmers manage agricultural risks (insurance schemes). However, there are important opportunities to make current risk management strategies more effective and to expand risk management capabilities around integrated risk management approaches. The analysis in this report finds that the agricultural insurance market will not expand rapidly under the current legal framework for financial services, but other financial instruments and budgeting mechanisms could be combined to address the government´s need for funds to compensate producers for losses triggered by different types of hazards. To this end, a risk financing strategy in Bolivia should be structured around an understanding of the probability of occurrence and the severity of hazards, and it should combine ex-ante instruments and ex-post measures to smooth the costs of risks and minimize cost fluctuations.

Along with risk transfer mechanisms, there are opportunities to continue strengthening the capacity of INIAF and SNIAF (including public and private actors) to develop, validate, and promote technologies and practices that reduce agricultural risk. Continued investment in irrigation and water management will be critical for increasing productivity, reducing vulnerability, and maintaining productivity gains. Improved water-use efficiency (and energy efficiency) and watershed conservation and protection are requirements for any such investments to be sustainable in the long term.

Reducing the environmental footprint of agriculture—In Bolivia, agricultural activities have increased water pollution, competition for water, and soil degradation, undermining biodiversity, threatening a range of social and economic interests, and contributing to climate change (through greenhouse gas emissions). These impacts are mainly the result of the expanding agricultural frontier and the intensification of agricultural activities.

As illustrated in this report, there are important opportunities to strengthen the government's role as a definer, enabler, funder, and regulator of environmental mitigation in agricultural investments. In this regard, particularly relevant steps for government include the alignment of growth and environmental policies and the improvement of national, regional, and local capacity for sustainable land-use planning and management, such as participatory local processes and the development of decision-support systems and incentives that facilitate the design of climate-smart agricultural landscapes.

However, approaching social and environmental challenges merely from the perspective of the government's roles—as a definer and enforcer of labor and environmental legislation, as a driver of land-use planning processes at the territorial level, or as an enabler of improved environmental performance—as necessary as it may be—is still insufficient. The collective commitment of the private sector is also required to improve the social and environment footprint of agriculture (for example, by adopting and complying with agreed environmental and social principles, particularly in subsectors with a large environmental and/or social footprint such as industrial commodity production, cattle ranching, and quinoa production).

This report identifies at least four major opportunities that can prevent future agricultural expansion from repeating the mistakes of the past. First, Bolivia's public and private sector can learn much from the

well-documented negative effects of unsustainable commercial agricultural development in faster-growing nations of Latin America and the Caribbean and other regions, as well as from the emerging approaches to reverse those effects. Equipped with that information, Bolivia's public and private actors can make systemic changes to move agricultural industries onto a more sustainable growth path. Second, some farmer organizations are already leveraging environmentally sustainable practices that serve as proof of concept to bring those practices to scale. Third, Bolivian farmers' ancestral knowledge of balancing nature and agriculture should be supported and more broadly disseminated. Fourth, environmental organizations and financial institutions have progressed substantially on sustainability, becoming vast sources of knowledge and best practices from which Bolivia can certainly benefit.

v) Strengthening public institutions

Efforts to address challenges and opportunities to ensure an inclusive and sustainable agricultural growth pattern could pay enormous dividends, but implementation will be demanding. Success in responding to Bolivia's emerging agricultural opportunities and challenges will require effective policy, aligned with institutional capacity. During the last two decades, Bolivia has established new institutions and strengthened existing ones to improve the delivery of critical services to the agricultural and food sector. These efforts must continue and even intensify as the agricultural and food sector and risks evolve and opportunities emerge domestically and abroad. Maintaining continuity in technical staff and limiting political interference will be centrally important to these efforts.

Aside from strengthening the capacity to provide key services to the sector, it is essential to strengthen the capacity for evidence-based policy making and investment planning; monitoring, policy analysis, and program evaluation; recognizing food emergencies and agriculture and food security risks; and using all of these capacities for effective policy action and program implementation. Policy makers require effective assessments of the benefits and tradeoffs of specific policies (related to export and input markets, price interventions, and the roles of state-owned enterprises in agriculture, for instance) as well as a broad understanding of the evidence on policies and strategies that are likely to be effective in achieving agricultural growth, competitiveness, and food security objectives.

Better data collection is a key requirement for better evidence to support better policy and planning. For example, enhanced data collection is a requirement to monitor gains in agricultural productivity at a more informative scale (from the macro-region to the departmental and lower levels) and develop better estimates of TFP.

vi) Public-private sector collaboration

A key condition for achieving sustainable and inclusive agricultural growth is to make collaboration between the public and private sectors the basis for continued progress. Agriculture is fundamentally a private activity. The largest investments for supporting growth of the agricultural sector into the future will come from the private sector (including large, medium, and small-scale producers and processors), although public spending will also be essential. The coordination of public and private efforts opens important avenues for promoting innovation and piloting comprehensive approaches that enable the convergence of sustainable and inclusive growth objectives. This collaboration should be institutionalized in such a way that it becomes the foundation for advancing the creation of prosperity and wealth in rural Bolivia.

Table 0. Approaches to enhance the effectiveness of market-oriented agricultural development in Bolivia

Market opportunities	Market-Oriented Production Levels 1-3 (Products serving domestic markets low & high value)	Level 2-3 Industrial commodity production for domestic food, feed and biodiesel uses	Levels 4-6 Non-traditional exports (beef, cocoa, coffee, brazil nuts, quinoa, etc.)
Current development pathways			
Strategic focus	Expand land frontier Intensify input use Import/export restrictions in some commodities Price interventions	Expand land frontier Intensify input use Import/export restrictions in some commodities Price interventions	Expand land frontier Intensify input use Import/export restrictions in some commodities Price interventions
Smallholder inclusion	High	Low	High
Job opportunities under current approaches	Low	Medium	Low-Medium
Tradeoffs	Short-term productivity gains Little incentives for innovation & technological change Land & water deterioration Deforestation (associated mainly with cattle ranching)	Short-term productivity gains Little incentives for innovation & technological change Land grabbing Marginalization of small-scale producers Large deforestation and ecosystem deterioration	Short-term productivity gains Little incentives for innovation & technological change Land & water deterioration Deforestation (associated mainly with cattle ranching)
Opportunities to enhance effectiveness			
Sectoral strategies			
Productivity	Increase productivity via efficiency gains (technological adoption & innovations)	Increase productivity via efficiency gains (technological adoption; technology transferring mainly for small-scale producers)	Increase productivity via efficiency gains (technological adoption & innovations)
Competitiveness	Market-orientation	Improved logistics/cost-efficiency	Quality differentiation/cost efficiencies
Approaches	Value chain (VC) prioritization and development (territorial focus) Job creation opportunities via investments upstream/downstream the value chain Support to farmer collective action Seek opportunities for inclusion of nutrition considerations Seek opportunities for linking VC development with broader local economic development	Landscape approaches Support to farmer collective action (small-scale producers)	Value chain (VC) prioritization and development (territorial focus) Job creation opportunities via investments upstream/downstream the value chain Support to farmer collective action Targeted market promotion & sanitary diplomacy Seek opportunities for linking VC development with broader economic development
Sustainability	Knowledge and technology transferring for climate and sustainable technologies	Adoption of principles of responsible investments Inclusive business models Enhanced landscape planning and management Risk management strategies	Knowledge and technology transferring for climate and sustainable technologies
Transversal: critical common & sectoral enablers			
Effective public and private sector innovation and technology transferring system Key productivity infrastructure Enabling trade policies Coordination, information and systematization of learnings Public-private sector collaboration			

Abbreviations and Acronyms

ASA	Advisory Services and Analytics
APS	Insurance and Occupational Pension Authority (Autoridad de Fiscalización y Control de Pensiones y Seguros)
BHAG	Crop Water Balance Model (Balance Hídrico Agrícola)
CAN	Andean Community of Nations (Comunidad Andina de Naciones)
CIAT	International Center for Tropical Agriculture (Centro Internacional de Agricultura Tropical)
CADENA	Committee for the Attention of Natural Disasters and National Emergencies (Comité de Ayuda a Desastres y Emergencias Nacionales)
CAF	Andean Development Bank (Corporación Andina de Fomento)
CAIPJ	Domestic Internal Supply and Fair Price Certificate (Certificados de Abastecimiento Interno a Precio Justo)
CIP	International Potato Center (Centro Internacional de la Papa)
CRI	Climate Risk Index
CRIAR	Creation of Agrifood Initiatives (Creación de Iniciativas Agroalimentarias Rurales)
DBI	Doing Business Indicators
DS	Supreme Decree (Decreto Supremo)
EBA	Enabling the Business of Agriculture
ECLAC	Economic Commission for Latin America and the Caribbean
ENA	National Agricultural Survey (Encuesta Nacional Agropecuaria)
EMAPA	State Agency for Agricultural Marketing (Empresa de Apoyo a la Producción de Alimento)
ENDAR	National Strategy for Agricultural and Rural Development (Estrategia Nacional de Desarrollo Agropecuario y Rural)
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
FSL	Financial Services Law
FDI	foreign direct investment
FOB	free on board
FONADIN	National Fund of Integral Development (Fondo Nacional de Desarrollo Integral)
GCI	Global Competitiveness Index
GDP	Gross Domestic Product
GHG	Green House Gas
GPV	Gross Production Value

ICT	Information and Communications Technology
INE	National Institute of Statistics (Instituto Nacional de Estadística)
IMF	International Monetary Fund
IDB	Inter-American Development Bank
INIAF	National Institute for Innovation in Agriculture and Forestry (Instituto Nacional de Innovación y Agropecuaria Forestal)
INRA	National Agrarian Reform Institute (Instituto Nacional de Reforma Agraria)
INSA	National Agricultural Insurance Institute (Instituto del Seguro Agrario)
LAC	Latin America and Caribbean
LPI	Logistic Performance Index
MDPyEP	Ministry of Production Development and the Plural Economy (Ministerio de Desarrollo Productivo y Economía Plural)
MDRyT	Ministry of Rural Development and Lands (Ministerio de Desarrollo Rural y Tierras)
MFE	Meta Frontier Efficiency
MMAyA	Ministry of Environment and Water (Ministerio de Medio Ambiente y Agua)
MT	metric ton
NDP	National Development Plan
NGO	Non-Governmental Organization
OTCA	Amazon Cooperation Treaty Organization (Organización del Tratado de Cooperación Amazónica)
PAHO	Pan American Health Organization
PAR	Rural Alliances Project (Proyecto de Alianzas Rurales)
PASARDI	Integrated Development Plan for the Agriculture and Rural Sector (Plan del Sector Agropecuario y Rural con Desarrollo Integral)
PC	Productive Complex (Complejo Productivo)
PDES	National Economic and Social Development Plan (Plan de Desarrollo Economico y Social)
PISA	Agricultural Innovation and Services Project (Proyecto de Innovación y Servicios Agrícolas)
PLUS	Land Management Plan (Plan de Uso de Suelo)
PO	Producer Organization
POP	Aligned Farm Management Plans (Plan de Ordenamiento Predial)
PPP	Public-Private Partnership
PRONAREC	National Irrigation Program with a Watershed Approach (Programa Nacional de Riego con Enfoque de Cuencas)
ROE	Return of Expenses

SAMEP	Agricultural Insurance for Municipalities with High Levels of Extreme Poverty (Seguro Agrario para Municipios con mayores niveles de Extrema Pobreza)
SAT	Early Warning System for the Agricultural Sector (Sistema de Alerta Temprana)
SENASAG	National Service of Agricultural Health and Food Safety (Servicio Nacional de Sanidad Agropecuaria e Inocuidad Alimentaria)
SENAMHI	National Service of Meteorology and Hydrology (Servicio Nacional de Meteorología e Hidrología)
SFA	Stochastic Frontier Analysis
SIRIC	Subprogram of Investments in Inter Communal Irrigation (Subprograma de Inversiones en Riego Inter Comunal)
SNIAF	National Agricultural and Forestry Innovation System (Sistema Nacional de Innovación Agropecuaria y Forestal)
SPF	Stochastic Production Frontier
TFP	Total Factor Productivity
TGN	General Treasury of the Nation (Tesoro General de la Nación)
UIPTLYM	Unit for Productive Infrastructure, Local Technology and Mechanization (Unidad de Infraestructura Productiva, Tecnología Local y Mecanización)
UPRA	Agricultural & Rural Planning Unit (Unidad de Planificación Rural Agropecuaria)
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
UPA	Agricultural Production Unit (Unidad de Producción Agrícola)
VA	value added
VRHR	Vice Ministry for Water Resources and Irrigation (Vice Ministerio de Recursos Hídricos y Riego)
WDI	World Development Indicators
WRI	World Resources Institute
WTO	World Trade Organization

1.

Introduction

Photo: Shutterstock

1.1. A context of dramatic change and emerging issues

Over the past half century, agricultural production systems have undergone sweeping change in virtually every region of Bolivia. To cite just one example, during the 1950s in the Central Valley of Tarija Department, almost two-thirds of cultivated area was occupied by maize, wheat, and potatoes, followed by barley, peaches, and peas. The push toward modernization in the late 1970s and early 1980s led many Central Valley farmers to move into more commercially oriented production. By the mid-1980s, production of many formerly minor crops had expanded, including grapes, market vegetables, and animal feed crops such as alfalfa and oats. Maize, wheat, and potatoes were still the most common crops, but they occupied only 26 percent of cultivated area.[4] Subsequent decades saw high levels of commodity specialization as increasing numbers of producers took up commercial dairy production and horticultural crops, including grapes to supply the growing wine industry. Not all farmers followed suit. Today in the Central Valley traditional subsistence agriculture persists alongside modern commercial agriculture.

Other shifts in agricultural production patterns have occurred throughout Bolivia, but the most striking changes occurred in the 1980s and early 1990s in the lowlands. In the lowlands, particularly in eastern Bolivia, commercial agriculture expanded dramatically, largely based on the production of oilseeds (along with some food crops such as beans) and commercial livestock.

These shifts have been driven by multiple forces, both on the demand side (income growth, migration, urbanization, changing dietary preferences, changing food spending patterns) and the supply side (evolving agroclimatic factors, technological innovation). The dynamics of agricultural transformation and modernization have varied across Bolivia's diverse geography, giving rise to today's highly diversified agricultural sector. The sector is extremely heterogeneous, not only in terms of structure but in terms of performance and links to socio-cultural traditions (Box 1).

The transformation of the agricultural sector has occurred in tandem with the transformation of the overall economy. As GDP per capita has risen in Bolivia, the contribution of primary agriculture to national GDP has declined in percentage terms, falling from 15.7 percent in the late 1980s to 12.2 percent in 2019. This decline has proceeded at a much slower pace than in other countries in the region and has virtually ceased since 2014, following contraction of the mining/gas sector.[5]

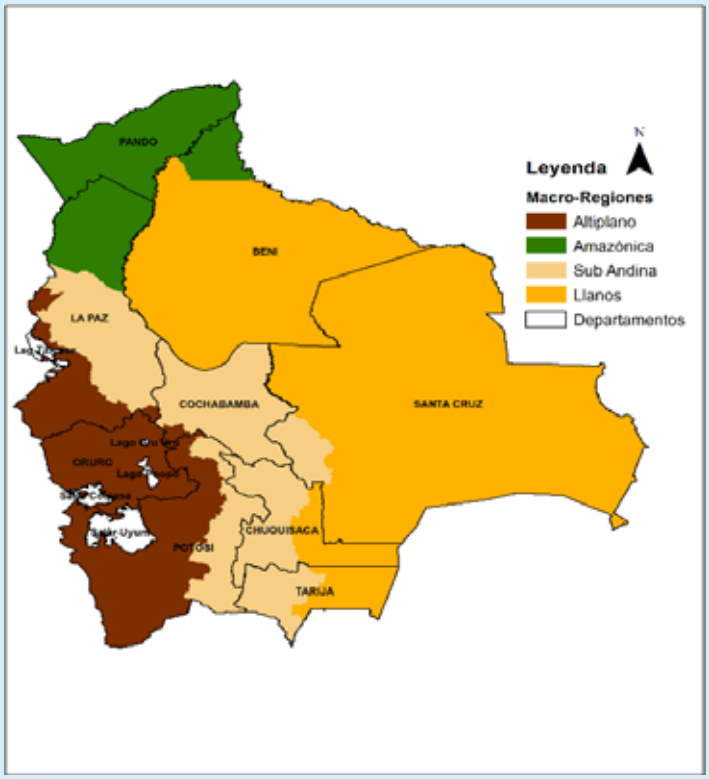
The relevance of agriculture in a rapidly urbanizing Bolivia

Investing in cities is an emerging priority for policy makers in Bolivia as urbanization continues to gain momentum. A large share of Bolivia's poor live in the areas surrounding its three largest cities. Evidence also clearly shows that the economic prosperity of cities and metropolitan areas benefits small towns and could certainly influence prosperity in nearby rural settings.

4 Turner, K., Davidson-Hunt, I. & Desmarais, A., (2017). Agrobiodiversity, Rural Transformations and Household Experiences of Globalized Change: A Case Study from Southern Bolivia. Rural Landscapes: Society, Environment, History. 4(1), p.1.

5 The higher relative growth of other sectors, in particular, the extractives and non-tradeable sectors, and their recent contraction can in part explain these trends.

Box 1. Bolivia's geographical regions and their role in agriculture



Bolivia has four geographical macro-regions spread across the 1,098,580 square kilometers within its borders: the Andes and western arid highlands (Highlands Region); the semi-tropical valleys in the middle third of the country (Sub-Andean Region); the eastern tropical lowlands (Lowlands Region); and the northern tropical forest, with its characteristic evergreens and rivers (Amazon Region).

Highlands (Altiplano) Region. Located between the two major Andean mountain ranges—the Cordillera Occidental and the Cordillera Oriental—the altiplano ("high plateau") covers about 28 percent of the national territory, with a large area of La Paz, Oruro, and Potosi Departments located higher than 3,000 meters above sea level (masl). Nearly 40 percent of the country's population lives in this region, mainly around the city of La Paz. The Altiplano is arid in the south but served by Lake Titicaca in the north. Small-scale farming predominates, with a focus on raising llamas and sheep and cultivating suitable crops such as quinoa, potatoes, and maize. Farmers engage in subsistence production and some commercial production for domestic markets, with the exception of quinoa, which became a popular export product during the present decade. Although land is abundant, this region is arid, and water scarcity remains an important natural constraint on increasing agricultural productivity and expanding production.

Sub-Andean Region (Región Sub-Andina). The lower eastern slopes of the Cordillera Oriental, known as the Yungas, comprise the semi-tropical Sub-Andean Region, which covers 15 percent of the national territory. It has a temperate climate, many valleys (Cochabamba, Chuquisaca, and Tarija Departments), and its numerous rivers drain into the Amazon Basin. The diversity of microclimates in the valleys make them very suitable for growing less extensive crops such as fruits, vegetables, and coffee. Tarija is well known for grape and wine production. The Bolivian valleys also face natural challenges such as the erratic distribution of rainfall throughout the year.

Lowlands Region (Llanos). In this region (spanning Pando, Beni, and Santa Cruz Departments), the northeastern plains cover more than half of the national territory, with tropical grasslands that are well suited to extensive livestock production. The tropical lowlands in the southeast in Santa Cruz Department have seen a major expansion of agriculture. Typical crops include sugarcane, soybeans, and maize. The Gran Chaco province in Tarija Department is sometimes considered a separate geographical region; otherwise it is included within this region.

Amazon Region (Región Amazonica). This region is characterized by tropical forest in the north (Pando, northern Beni, and La Paz Departments). Typical crops include yucca (cassava), sugarcane, rice, and maize (rubber was a major crop in the past). Demographic density is low compared to the other regions.

Throughout Bolivia, diversity is an underused resource. Bolivia's geographic diversity translates into significant agricultural biodiversity, and in fact Bolivia (particularly the Highlands) is the center of origin of a wide range of crop species. Much of this biodiversity has been underused or neglected.

Agriculture and the farming population are concentrated in different areas. Because the lowlands possess most of the land that is easily used for agricultural activities, this region has experienced the most widespread conversion of land to agricultural uses. People have continuously migrated from other regions and countries to Santa Cruz in search of economic opportunities and inexpensive land. The scope of this transformation is apparent from census data: 9 percent of Bolivia's cropped area was in Santa Cruz Department in the 1950s; by 2013, that share had risen to 60 percent. By contrast, the farming population is concentrated in the Highlands (La Paz, Oruro, and Potosi Departments), where nearly 50 percent of the population above the age of 8 formed part of an agricultural production unit in 2013, versus 13.5 percent in Santa Cruz.

Economic activity in these four geographical regions is anchored around Bolivia's three largest cities. La Paz, Cochabamba, and Santa Cruz together account for 70 percent of national GDP and almost two-thirds of the national population. Agriculture in these same departments delivers approximately 72 percent of agricultural GDP, and Santa Cruz generates 50 percent of the sector's GDP (2019).

Agriculture and the rural space will continue to command the attention of policy makers in Bolivia for several reasons, even as urbanization gains momentum. First, agriculture is a proven source of economic growth. In recent years agriculture has compensated for downturns in other primary sectors and continued healthy rates of growth in agriculture will increase the overall resilience of the Bolivian economy. Second, a diversified agricultural sector has the advantages of further reducing dependency on the mining and gas sectors, contributing significantly to inclusive growth, adding value, improving the number and quality of jobs on and off of the farm, and addressing nutritional challenges. Third, agricultural growth in Bolivia has proven to be pro-poor, and if it slows, an important means of reducing poverty will be lost. Fourth, because climate and other shocks affecting agriculture can significantly disrupt economic growth and sustained poverty reduction, in addition to jeopardizing food security, building a resilient agricultural sector is critical to sustain gains on those fronts. Finally, although policy makers will want to support agricultural growth, they will not want that growth to come at the expense of the nation's irreplaceable natural resources and compromise the future of generations of Bolivians.

Efforts to address these issues will be rewarding but demanding. In the years to come, agricultural transformation and modernization in Bolivia are expected to accelerate, creating new opportunities for farmers, firms, and overall sectoral growth. Those opportunities are accompanied by a range of challenges, including the heterogeneity of Bolivia's geography and agroclimatic conditions, constraints to growth in productivity and competitiveness, and the need for resilience in a changing climate. Bolivia's response to emerging agricultural opportunities and challenges will require effective policy, aligned with institutional capacity, targeted investments by the public and private sector, and the implementation of strategies for successfully managing emerging risks (climate is just one example) and unwanted impacts (such as the loss of biodiversity).

1.2. Objectives, scope, and audience

As Bolivia continues its transition to an increasingly urbanized economy, ensuring balanced urban/rural development is crucial to achieving an inclusive and sustainable growth pattern. The creation of opportunities to support wealth and inclusion in the rural space, including opportunities in the agricultural sector—the anchor of rural activity—will remain critical to Bolivia's development agenda in the years to come.

In aggregate terms the agricultural sector in Bolivia has experienced rapid growth, particularly in the last decade. The two important challenges for the sector are to (1) sustain growth into the future and (2) ensure that the gains from agricultural growth translate into stronger economic inclusion and environmental sustainability. For example, despite significant gains in poverty reduction, the average income of the population under the poverty line needs to increase by 75 percent to lift them above poverty. Furthermore, the continuation of current patterns of agriculture growth, based on the expansion of agricultural land and increased use of inputs, are likely to severely compromise the future provision of key ecosystem services and exacerbate climate-related challenges if not properly guided. A better understanding of recent sectoral performance trends and of the drivers and disruptors of growth in the agriculture and food system is helpful to distil lessons and provide directions for the future.

With this background in mind, this report aims at analyzing the ongoing transformation and performance of Bolivia's agriculture and food system and highlighting opportunities and avenues for enhancing the sector's productivity, competitiveness, and resilience. Taking into account relevant global and domestic developments, drivers, and disruptors, the report examines the constraints to, and transformational

opportunities for, the Bolivian agricultural sector and the broader food system, looking at their potential contribution to stronger economic inclusion and environmental sustainability.

This report makes use of the available literature, econometric exercises, the analysis and synthesis of pertinent data, expert assessments, structured case studies, and examples of good practice that have emerged in Bolivia and elsewhere to draw lessons for addressing the opportunities, challenges, and risks associated with the transformation of agriculture and food systems. The analyses and information presented here also adopt a territorial perspective in assessing spatial features that contribute to (or detract from) the dynamism of agriculture in each of Bolivia's four macro regions and in identifying policy opportunities. The report presents deep dives and insights into five thematic areas:

- **Drivers and disruptors of agricultural growth and sectoral transformation.** Chapter 2 explores this thematic area by examining multiple dimensions of agriculture's role in Bolivia's transitioning economy. It synthesizes evidence on the changing dynamics of Bolivia's agri-food systems. With a view to the future, it considers the demand and supply factors that influence the size and configuration of the sector, and highlights opportunities for agriculture to support national development objectives more effectively.
- **Agricultural productivity patterns and trends across territories.** The land expansion model that has dominated agricultural growth in Bolivia in the last few decades has featured limited productivity gains, particularly in terms of labor and land productivity. Aggregate figures at the national level conceal important regional disparities in productivity performance, however. Chapter 3 explores this thematic area by providing a broad view of trends in agricultural performance and trade and outlining the major features of production systems in Bolivia's four macro-regions. Chapter 4 approaches the issues of productivity and efficiency through econometric analysis—Stochastic Frontier Analysis (SFA) and Meta Frontier Estimates (MFE). This chapter identifies the main determinants of technical efficiency in Bolivia's four macro-regions and highlights important differences in efficiency between regions, crops, and groups of producers. These analyses, although highly data-driven, are relevant for understanding the current status of productivity efficiency at the regional and crop level and for identifying opportunities to address performance gaps. These analyses are also highly relevant for informing policy makers of knowledge and information gaps related to the measurement and monitoring of productivity performance in Bolivia.
- **Competitiveness constraints within value chains and across macro-regions.** In Bolivia only a small number of agricultural commodities are integrated with global value chains, and even those commodities encounter constraints that hinder their competitiveness. With the goal of understanding the factors that determine competitiveness, Chapter 5 examines the competitiveness of agriculture in Bolivia in relation to global benchmarks and comparator countries and takes a deeper look at competitiveness constraints and opportunities in key value chains for agriculture and agribusiness.
- **Insights on the policy framework supporting productivity and competitiveness.** Chapter 6 looks at the current policy framework and public spending on agriculture in Bolivia. It gives particular attention to the enablers of productivity and competitiveness and strategies for integrating more producers into value chains and improving value chain performance, including the integration of nutritional considerations into value chains and into agricultural interventions more broadly.

- **Climate as a disruptor of sustained growth gains and opportunities to reduce the environmental footprint of the sector.** Chapter 7 presents an overview of the challenges to agriculture posed by climatic factors. It highlights how climate smart agriculture (CSA) can help the sector to adapt to and mitigate climate change. It focusses attention on the risk transfer instruments that are currently in place in Bolivia to manage climate risks. It also highlights opportunities to reducing the agricultural sector's environmental footprint.

A concluding section synthesizes the findings and the implications of the analysis. It identifies policies and investments that will enable agriculture to grow inclusively and sustainably.

In sum, this report presents a comprehensive view of the agriculture and food sector in Bolivia. It combines both high-level and in-depth analyses of themes of relevance and interest to a broad audience, including development practitioners, policy makers, academics, students, private actors, and all parties interested in enhancing the contributions of the agriculture and food sector to inclusive and sustainable growth in Bolivia.

2.

Bolivia's Agriculture in Transition

Photo: Programa de Alianzas Rurales (PAR), EMPODERAR

Table 1. Average annual growth rate total and per capita GDP (%): Bolivia vs Regional and Structural Peers (Period 2003-2017)

Country	GDP Per Capita	Total GDP
Bolivia	2.8	4.5
Regional Peers & Region		
Brazil	1.3	2.3
Colombia	2.8	4.1
Paraguay	2.7	4.2
Peru	4.0	5.1
Latin America & the Caribbean	1.6	2.7
Structural Peers & Income Group		
Kazakhstan	1.7	3.4
Ecuador	4.4	5.7
Ghana	3.9	6.4
Mongolia	1.5	4.3
Cameroon	5.8	7.5
Lower Middle	4.1	5.7

Source: Calculations based on WDI data.

2.1. Bolivia's economic performance in the regional and structural context

In less than two decades, Bolivia has emerged as a regional economic star to become one of the fastest-growing economies in the Latin America and the Caribbean (LAC) Region. Real GDP growth in Bolivia has been among the highest in the region, growing by 4.5 percent per year on average between 2003 and 2019.[6] This rate is well above the regional average and surpasses several of Bolivia's regional peers.[7] During 2006–19, per capita GDP in Bolivia increased from US$1,227 to US$3,552, allowing the country to achieve lower-middle-income status in 2010. While these achievements are outstanding in the regional context, when Bolivia is assessed in the context of its structural peers[8] and income group, the results are somewhat less remarkable (Table 1).

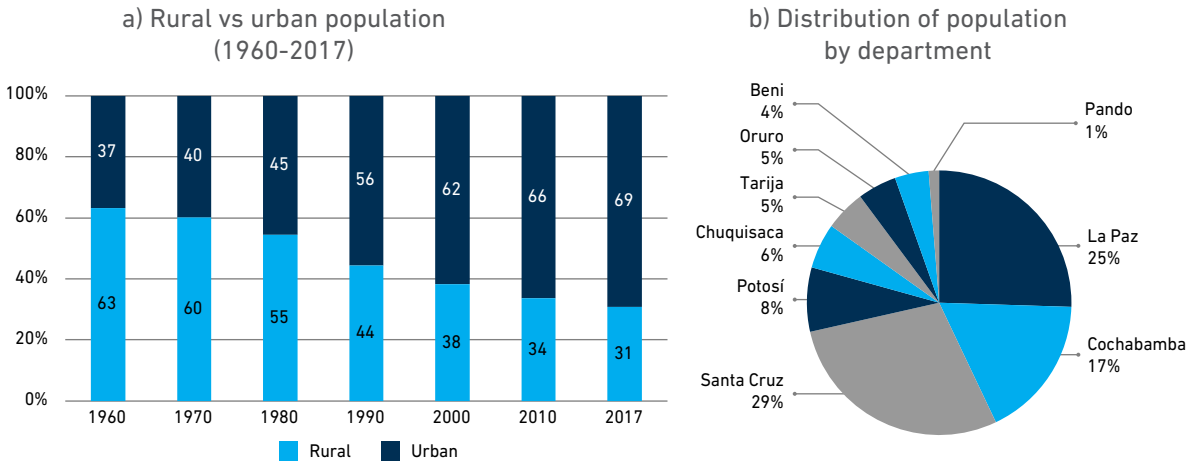
Rapid economic growth in Bolivia has been the result of a favorable international environment, moderate macro-economic policy, public investment, and private consumption. Private consumption has been fueled by the expanding urban middle class and young population (two thirds of the 2.6 million Bolivians between the ages of 16 and 29 live in urban centers). Bolivia's rate of urbanization is converging with that of its regional peers. In 2017, about 68 percent of Bolivians lived in urban areas, up from 37 percent in 1960. Between 1950 and 2012, the country's urban population grew

6 Recent figures published by the National Institute of Statistics (INE) estimated GDP growth in 2018 at 4.22 percent.

7 Regional peers: South American middle-income commodity exporters with more than 5 million inhabitants, excluding Venezuela.

8 Structural peers: non-fragile, middle-income oil exporters with hydrocarbon exports between 25 and 65 percent of good exports and population between one and on hundred million inhabitants.

Figure 1. Rural vs urban population, Bolivia



Source: a) WDI, b) INE

at an annual rate of 3.7 percent, almost five times as fast as population growth in rural areas. As noted, urbanization in Bolivia has focused on peri-urban Santa Cruz, Cochabamba, and La Paz, the three largest cities where more than half of the urban population resides (World Bank 2015).[9] Between 1992 and 2012, the average annual growth in the peri-urban population was 8.2 percent in Cochabamba, 7.4 percent in Santa Cruz, and 4.1 percent La Paz.

Bolivia's positive economic performance has translated into impressive social advances since the mid-2000s. Growth has undoubtedly been inclusive, with evidence of significant improvements in income redistribution and reductions in poverty and extreme poverty. The gains in income have allowed the emergence of a growing middle class, which official figures show to have increased from 35 percent in 2005 to 58 percent in 2017. Poverty has fallen from 63 percent of the population (2003) to 36.4 percent (2017) and 34.6 percent (2018).[10] The Gini coefficient of inequality, formerly one of the highest in the region, also fell dramatically from the early 2000s to 2011 (from 0.6 to 0.46), but it has changed less noticeably in recent years, reaching a value of 0.44 in 2017. Between 2000 and 2014 income growth was the most pronounced determinant of poverty reduction, both in rural and urban areas. In the years since then, as poverty has declined more slowly, income redistribution has come to play a more critical role in reducing poverty (World Bank 2019).

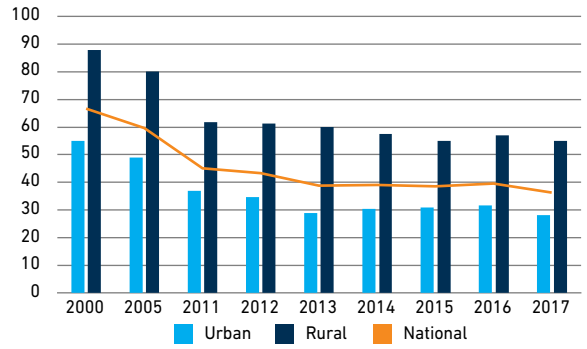
The gains in reducing rural poverty have been particularly remarkable; rural poverty rate was almost 90 percent in the 1990s and had declined to 55 percent by 2017. In urban centers, 29 percent of people are poor; population wise, the largest number of poor people in Bolivia now live in the urban centers (54 percent of the country's poor). However, it is the rural areas where moderate poverty and extreme poverty are still most highly concentrated. Sixty-two percent of the extreme poor live in rural areas. Poverty is not uniformly distributed across Bolivia's geographical areas (Figure 2c). Poverty rates are highest in the

9 Urbanization Trends in Bolivia: Opportunities and Challenges, May 2015. The World Bank.

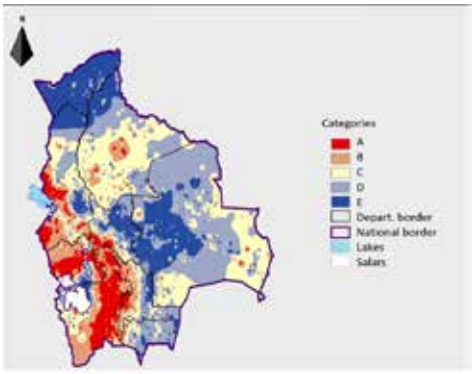
10 National Institute of Statistics (Instituto Nacional de Estadísticas, INE), website.

Figure 2. Poverty in Bolivia

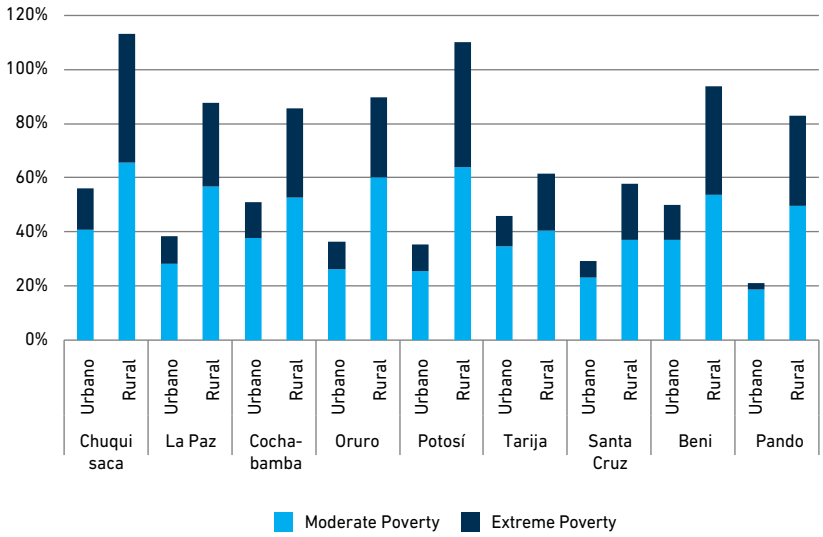
a) Poverty incidence (national, rural, urban; %), Bolivia, 2000–17



b) Community characterization of rural poverty in Bolivia



c) Decomposition of poverty by department, 2017 (%) (urban/rural)



Source: (a) and (c) calculations based on INE data; (b) Ministry of Development Planning

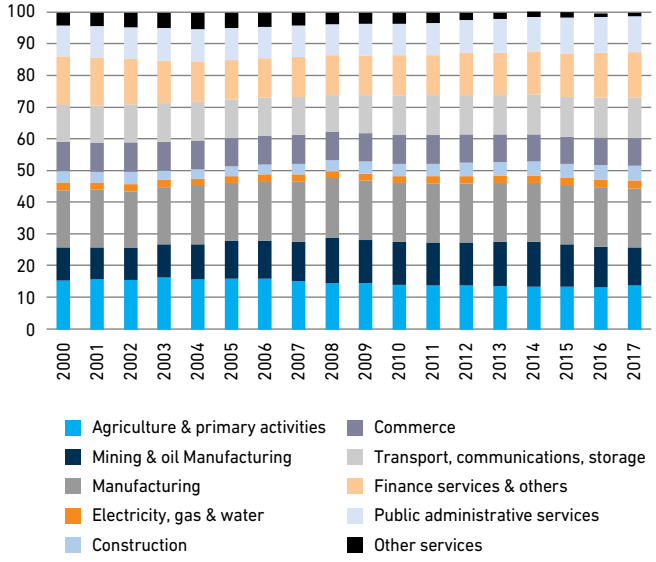
departments of Chuquisaca and Potosi, with poverty rates of 52.9 and 51.2 percent, respectively in 2017; and they are lowest in Santa Cruz Department, with a rate of 25.6 percent. The Potosi, Oruro and La Paz Departments in the Highlands Region; Pando and Beni in the Amazon Region; and Chuquisaca in the Sub-Andean/Lowlands Regions experienced the highest rates of rural poverty and extreme poverty (Figures 2b and 2c). Poverty disproportionately affects indigenous people, who comprise 42 percent of the population (52 percent of indigenous people live in rural areas). Beyond ethnicity, gender and prevailing rural-urban gaps exacerbate poverty.

2.2. Agriculture in a transitioning economy

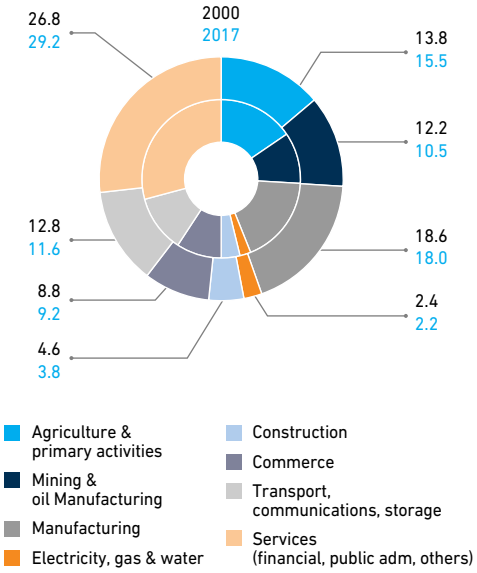
Structural change is occurring very slowly in Bolivia's economy. The composition of GDP has remained

Figure 3. Sectoral decomposition of GDP, Bolivia, 2000-2017 (%)

a) Sectoral decomposition, 2000–17



b) Structural change, 2000 vs 2017 (%)



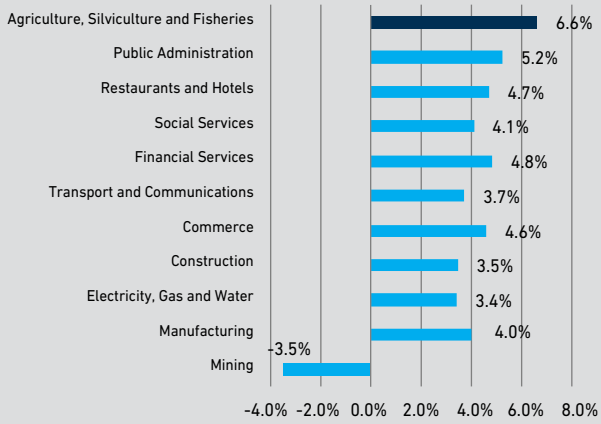
relatively unchanged since the early 2000s (Figure 3a, 3b). Primary activities such as mining/gas continue to dominate economic activity; in fact, Bolivia is still one of the most commodity-dependent countries in the LAC Region. In 2017, the share of GDP of the combined mining/hydrocarbon sector reached 12.2 percent and contributed 62.2 percent of total export value. The sector grew at an average of 6 percent during 2000–17, and despite the government's desire to diversify the country's export base, limited progress has been achieved—the share of minerals and hydrocarbons in the value of exports rose 22 percent points between 2003 and 2016.

In a context of volatility of commodity prices, the sector's growth has shown more dynamism during the last four years (6.6 percent during 2016–19) than other sectors, such as construction, transport, agriculture, and services (private and public) that registered less dynamism (Table 2.a) and more incidence in the average GDP growth (Table 2.b). Furthermore, the value of mining and gas exports has declined significantly, falling from US$12.89 million at its peak in 2014 to US$7.8 million in 2017.

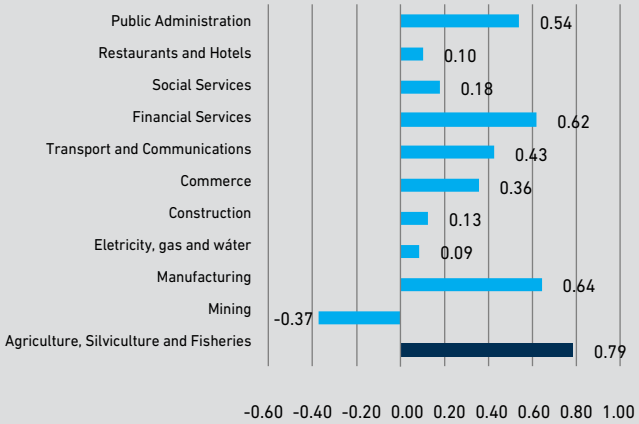
The transformation of the agricultural sector in Bolivia suggest that the country has followed the general development pathway seen in economies worldwide. This path is described in the *2008 World Development Report: Agriculture for Development* (World Bank 2008) as a series of stages in which economies transition from being *agriculture-based* to becoming *pre-transition*, *transition*, *urbanizing*, and ultimately *developed* economies. An important characteristic of this transition is that the share of agriculture in the economy and employment tends to gradually decline as an economy develops. The declining share of agriculture in the economy is consistent with the reallocation of labor from a highly labor intensive and low-productivity agricultural sector to other sectors where productivity is higher, such as manufacturing or services.

Table 2. Sectoral growth in Bolivia (%)

a: Sectoral GDP Annual Growth Rate 2016-2019[11]



b: Incidence of Sectors in the growth of the average GDP (2017-2019)



Source: Calculations based on INE data

Recent work by the World Bank and others has questioned the magnitude of the gains in productivity and economic growth from the reallocation of labor from agriculture to industrial sectors. The work highlights evidence that the potential gains may not be as large as they are often portrayed, and in fact they may be lower than previously thought. The evidence suggests that structural transformation may proceed more rapidly through efforts to support productivity growth on and off of the farm, to shift the labor market equilibrium higher.[12]

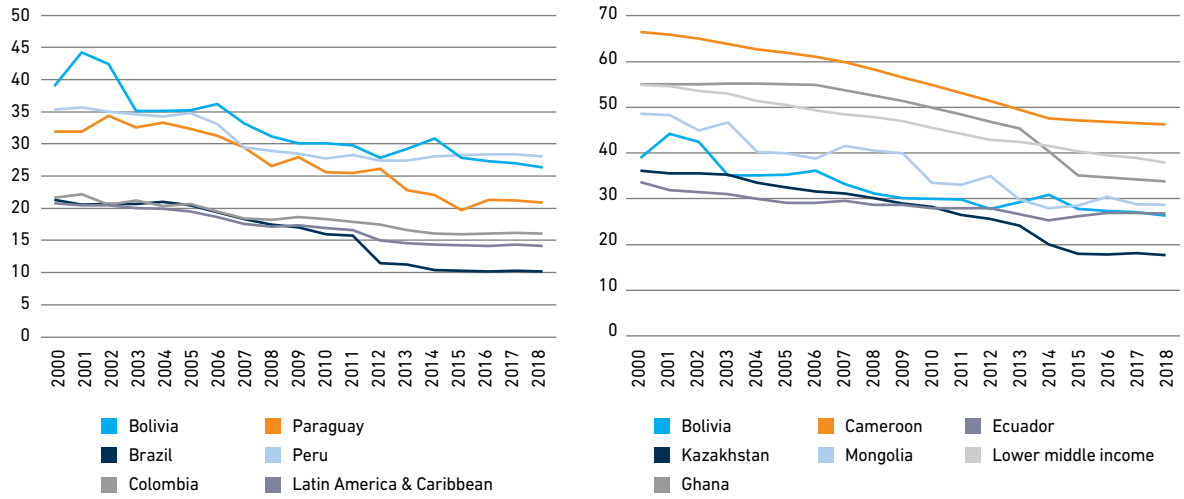
In Bolivia during the past 15 years, labor has moved from agriculture to manufacturing and services (Figure 4), often in the informal urban sector, yet agriculture continues to employ around one-quarter of the population, more than agriculture in Bolivia's regional peers, except for Peru. When Bolivia is compared with its structural peers, its share of agriculture in total employment in 2017 is similar to that of Ecuador, although the transformation of agricultural employment is happening more rapidly in Bolivia than in Ecuador. At the same time, this transformation is proceeding at a much slower pace in Bolivia than in other oil-dependent countries (structural peers) such as Mongolia and Kazakhstan. In Kazakhstan the share of agriculture in total employment has halved since the 2000s, contracting from 36 percent in the early 2000s to 18 percent in 2017. However, in comparison with other highly agriculture-based economies in the LAC region such as Nicaragua and Honduras, the speed at which labor is moving out of agriculture has been faster in Bolivia. In 1991, the share of agriculture in total employment in Bolivia, Nicaragua and Honduras was 40, 31, and 38 percent, respectively; in 2018, the respective figures were 28, 31, and 31.9 percent.[13]

11 Manufacturing includes categories such as: sugar & confectionary; milling & bakery products; wood & wood products; dairy products; fresh & elaborated meat; miscellaneous food products.

12 Harvesting Prosperity: Technology and Productivity Growth in Agriculture. World Bank, forthcoming.

13 Nicaragua is a country that has experienced a reversed trend since 2008, with agricultural employment increasing, after experiencing a rapid declining trend, prior to 2008.

Figure 4. Agriculture's share of total employment, Bolivia vs. regional and structural peers (2000-2018)



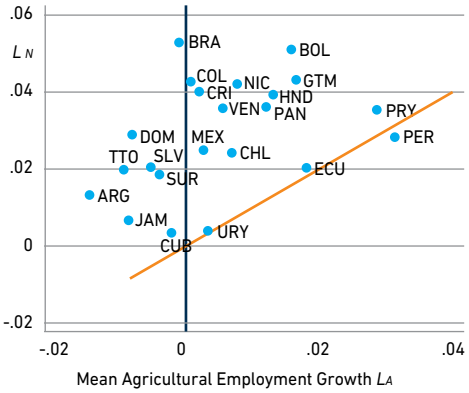
Source: WDI data

The diminishing share of agricultural employment in total employment over the longer term does not mean that agricultural employment in Bolivia is stagnant or declining. Figure 5a presents the results of a recent assessment by the Food and Agriculture Organization (FAO) of the structural transformation of agriculture in LAC. The figure displays mean growth rates of employment in agricultural and non-agricultural sectors. The red line is the iso-growth line: countries above it display faster growth in non-agricultural employment. Bolivia is at the top, with faster growth in non-agricultural employment than Ecuador, Peru, and Paraguay. Countries to the left of the blue line have experienced negative growth in agricultural employment, which emphasizes the structural transformation of their labor markets. This part of the figure shows that growth in agricultural employment has been positive in Bolivia; in fact, the share of primary agriculture in total employment in rural areas is higher in Bolivia than in all other LAC countries, signaling that in Bolivia the transformation of rural labor markets is still pending (Figure 5b).

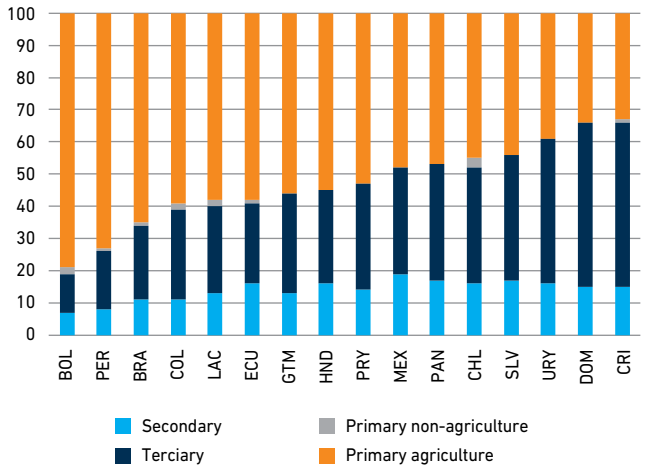
Figure 5c presents a composite picture of where Bolivia stands in its agricultural transition compared to other countries in LAC and its structural peers, based on changes in agriculture's share of value-added in total GDP and total employment. As the figure shows, although the share of agriculture value-added in total GDP is falling in Bolivia, it is not falling at a rate comparable to rates in urbanizing economies in the region. Paraguay, for example, has a slightly lower share of agriculture value-added in total GDP than Bolivia, but the share of agriculture in total employment is much lower. Furthermore, although the share of agriculture in total employment is similar in Bolivia and Ecuador, Ecuador has more successfully diversified its economy, with the share of agriculture in total GDP falling to the single digits. Kazakhstan, a structural peer that is highly dependent on oil and mining and has been showing symptoms of Dutch disease since the early 2000s, has rapidly moved people out of agriculture, mainly to the services sector, significantly reducing agriculture's presence in the overall economy.

Figure 5. Agriculture transformation in Bolivia

a) Growth agricultural and non-agriculture employment in LAC, 1984-2012.

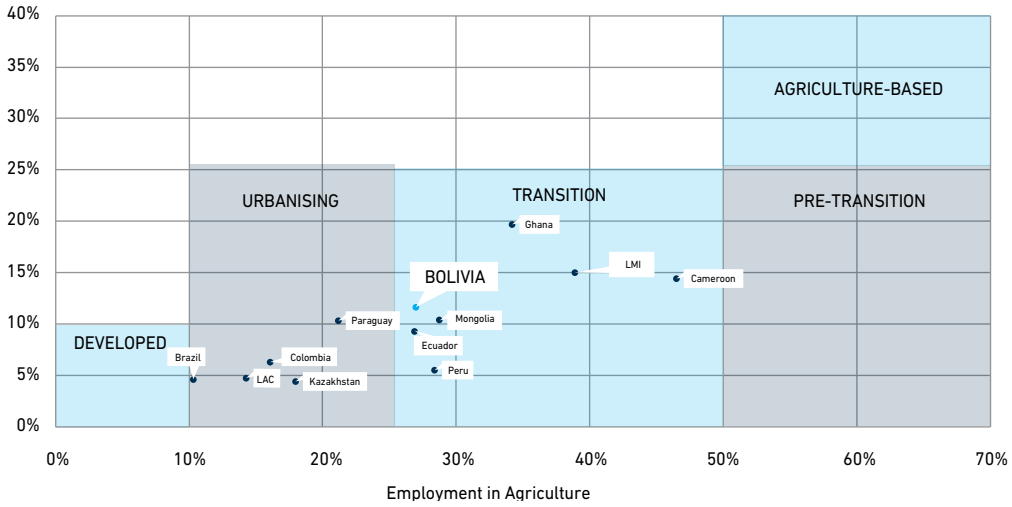


b) Rural employment by economic activity, 2016



Source: (a) FAO 2016; (b) OTI 2016

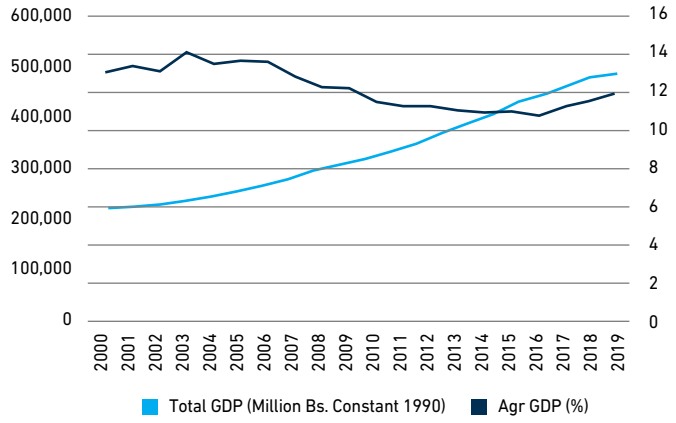
c) Agricultural transformation: Bolivia and its regional and structural peers



Source: Based on World Bank Development Report, published in 2007

Figure 6. Growth of agricultural value added, Bolivia, 2000-2017

a) Agriculture GDP as share of total GDP, 2000-2019



b) Ag GDP growth, Bolivia vs comparators 2000-19

Country	2000-2009	2010-2019
Bolivia	3.1	4.3
Regional Peers		
Brasil	3.9	3.5
Colombia	2.5	3.2
Paraguay	5.4	8.0
Perú	3.8	3.2
Latin America and the Caribbean	3.1	3.0
Structural Peers		
Ecuador	3.9	3.5
Kazaskhstan	4.5	2.7
Ghana	n/a	3.6
Cameroon	2.5	4.8
Mongolia	5.3	6.9
Lower middle income	3.9	3.4

Source: Calculations based on: a) INE, b) WDI

A declining share of agriculture in total GDP does not imply that the sector is not growing. On the contrary, the volume and value of agricultural production has grown steadily in Bolivia. During 2000–17, growth in agricultural GDP in Bolivia averaged 3.0 percent per year, higher than in most of the country's regional peers, and among the top rates of its structural peers, particularly during the present decade (Figure 6). During 2010–17, average annual growth in agriculture reached 4.3 percent, and the sector has grown faster since 2013, reaching an average annual rate of 4.9 percent.

Another important characteristic of the general pattern of agricultural transformation is that forward and backward linkages in the agricultural sector become stronger, while the share of the primary sector in total economic activity declines (World Bank 2008). Those forward and backward linkages are rarely estimated, however, although such estimates would provide a more accurate picture of the relevance of agriculture in an economy. To understand the "real" importance of agriculture, an "expanded agricultural value added" is estimated based on the methodology provided by Foster and Valdes (2015). Box 2 shows the results for Bolivia.

A distinguishing feature of Bolivia's agricultural transformation is that the growth strategy has been increasingly based on expanding the production of commodities to satisfy growing domestic and international demand. Consequently, the share of industrial agricultural products (particularly soybeans and soybean by-products) in total agricultural GDP rose from 7 percent to 22 percent between 1988 and 2017. Note, however, that much of this change in the composition

Box 2. Re-assessing the contributions of agriculture to Bolivia's economy (Expanded Ag GDP)

Estimation of the expanded agriculture value-added used the Input-Output matrix of Bolivia for 2012. Computed and made available by the National Institute of Statistics (INE), this matrix includes 35 economic activities and the transactions between them. The first five sectors—non-industrial agricultural products, industrial agricultural products, coca, livestock products and silviculture, and hunting and fishing—are considered together as the primary sector.

The estimated expanded value added for the primary sector is provided in Table 3. Note that the share of value-added increases by 5.35 percentage points, from 12.9 percent to 18.3 percent. The contribution of the forward linkages is even greater than the backward linkages, implying that other sectors such as manufacturing, and services rely much more on the primary sector for inputs, and the primary sector relies less on those sectors for its inputs.

Table 3. Value added of renewable primary sector and its linkages, 2012

Activity code	Activity Description	Share of sector in total VA (%)	Participation in FWD sectors (%)	Participation in BWD sectors at midpoint (%)	Forward and backward sum (%)	Participation in total expanded VA (%)
1	Non-Industrial Agricultural Products	5.808%	1.501%	0.142%	1.643%	7.451%
2	Industrial Agricultural Products	2.403%	0.679%	0.434%	1.114%	3.516%
3	Coca	0.624%	0.000%	0.001%	0.001%	0.626%
4	Livestock Products	2.847%	1.462%	0.088%	1.550%	4.397%
5	Silviculture, Hunting and Fishing	1.250%	0.968%	0.079%	1.047%	2.297%
	Total	**12.932%**	**4.610%**	**0.745%**	**5.355%**	**18.287%**

Table 4 illustrates the dependence of certain key economic activities on the primary sector. It is interesting to note that dairy products have a 30 percent dependence on the primary sector for inputs and a 70 percent dependence on other sectors such as sugar, machinery, and transportation and storage. Similarly, fresh and processed meat has a 65.6 percent dependence on the primary sector and 34.4 percent on other sectors. Much of the dependence of the primary sector is related to economic activity in livestock production.

Table 4. Dependence of key Economic Activities on Primary Sector

Sector	Dependence on Primary Sector	Dependence on Other Sectors
Restaurants & Hotels	7.74%	92.26%
Wood & Wood Products	26.68%	73.32%
Dairy Products	30.14%	69.86%
Milling & Bakery Products	34.46%	65.54%
Sugar & Confectionery	40.96%	59.04%
Fresh & Processed Meat	65.66%	34.34%
Miscellaneous Food Products	68.61%	31.39%

of agricultural GDP occurred in the late 1980s and 1990s, with little change since then.

The fastest-growing categories during 2000–17 were fisheries, forestry, and hunting, growing nearly 4 percent during the period, albeit from a low base, followed by livestock at 3.5 percent and industrial products at 3.1 percent. The value of industrial crops more than doubled during the same period, and growth in this category has been impressive since 2013 (Figure 7d).

The concentration on a few commercial crops, combined with the mechanization of production and the creation of economies of scale, translated into a significant expansion of agricultural area. Oilseeds and cereals represented 84.5 percent of agricultural planted area in 2016. Between 1996 and 2016, the cereal area grew by 4.1 percent on average, while oilseed area grew by 4.8 percent. The area planted to soybeans expanded by 191 percent over the last two decades, reaching 1.3 million hectares in 2016. As discussed in the following paragraphs, the evolution of food demand and overall food systems in Bolivia have had significant impacts on land use and crop/livestock patterns.

2.3. Evolution of food demands, food system modernization and nutritional challenges in Bolivia

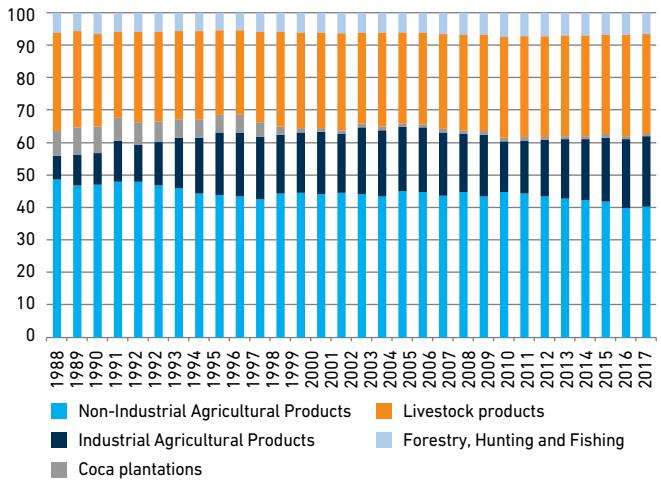
Changes in dietary preferences within Bolivia, resulting from urbanization, higher incomes, and women's increased participation in the labor force, have significantly influenced the foods that are produced locally and imported. Changes in dietary patterns in Bolivia resemble changes at the global level, such as the increased consumption of animal protein, added caloric sweeteners (especially in beverages), refined carbohydrates, ultra-refined highly processed foods, convenience foods for snacking, and edible oils used to fry foods.

Meat consumption in Bolivia has increased greatly, particularly per capita consumption of poultry, which reached 42 kilograms in 2016, up from 10 kilograms per capita 20 years earlier. Bolivia now has one of the highest rates of poultry consumption in LAC. Beef consumption has increased at an annual rate of nearly 3 percent since 2010 and stands slightly above global average consumption, but well below the regional average. Recent industry reports highlight that pork consumption has increased at nearly 10 percent each year in the last four years.

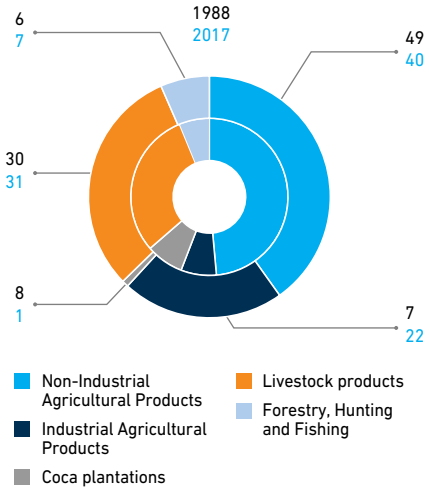
These changes in daily food consumption are reflected in agricultural production developments. Poultry production has exploded since 2000; it was nearly 270 percent higher in 2017 than in 2000. The same comparison for milk production shows a change of 75

Figure 7. Composition and growth of agricultural value added, Bolivia

a) AG GDP decomposition, 2000-2017

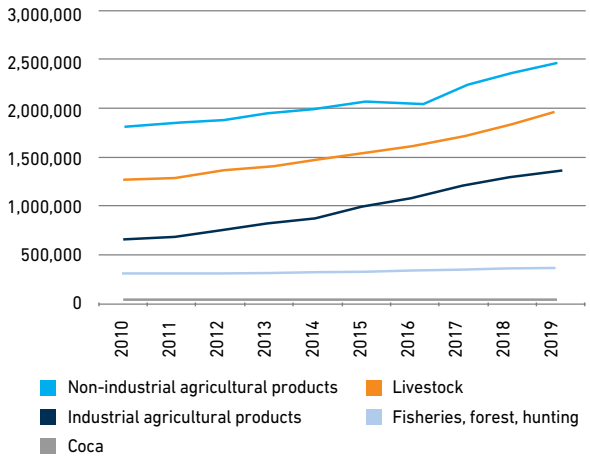


b) AG GDP, 1988 vs 2017



Fuente: a) FAO (2016); b) Organización Internacional del Trabajo (2016).

c) Growth by Ag Categories, (Bs thousand, constant 1990)

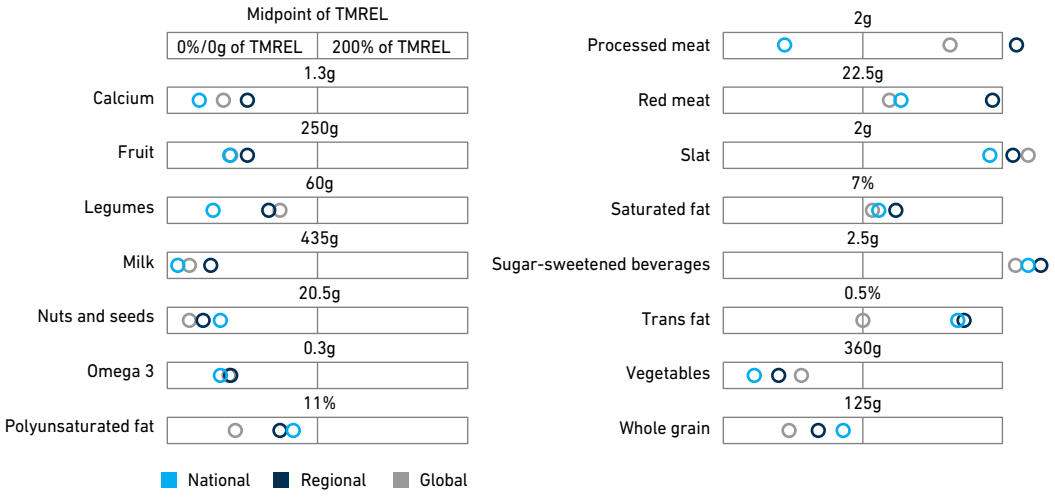


d) Average growth rates by Ag categories (%, in value terms)

Product Category	2000-2017	2016-2019
Non-Industrial Agricultural Products	2.5	6.6
Industrial Agricultural Products	3.1	7.9
Coca	1.7	-0.4
Livestock	3.5	6.8
Fisheries, Hunting and Forestry	3.9	2.3

Source: Calculations based on INE data

Figure 8. Dietary Composition, Bolivia versus global and regional averages



Source: Bolivia: Nutrition country profile. Global Nutrition Report, 2018

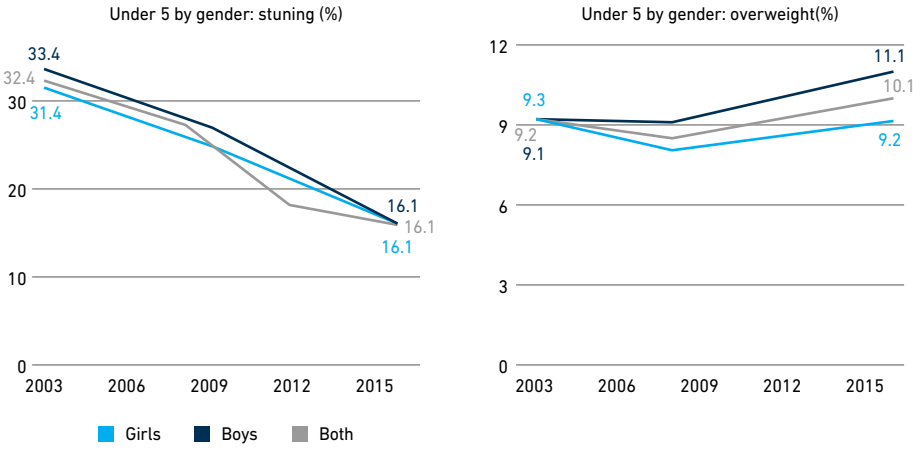
percent; for beef, it is 71 percent. Per capita sales of ultra-processed foods during 1999–2013 were low in Bolivia (41 kilograms per capita) compared to other countries in the region (Mexico, 160 kilograms; Chile 120 kilograms), but sales of these products have continuously increased across all LAC countries, with Bolivia experiencing the largest increase (+151 percent) (PAHO 2013). Rapid growth of the poultry and other meat subsectors have fueled the large expansion in production of oilseed crops, particularly soybeans. Consumption of sugar-sweetened beverages is below regional standards but higher than the global average, while consumption of trans fats is at par with the regional average and nearly double the global average. On the other hand, consumption of vegetables is well below regional and global averages and together with milk, fruits, and legumes presents important opportunities for consumption increases in Bolivia (Figure 8).

Changes in dietary patterns also imply changes in the places where people eat and buy food. Data from the Continued Household Surveys carried out by INE in 2003-04 and 2015-16 show that the share of food and drinks consumed outside of the home increased from 19.4 percent to 33.4 percent during the 12-year period, owing to an increased number of street food vendors and small restaurants, and more recently of international fast food outlets.

Data published by INE provide a picture of household food expenditure and show that Bolivians on average spend 27.06 percent of their income on food and non-alcoholic beverages, representing a slight change compared with data from 2007 (27.37 percent). Marked differences are observed only in the percentage of household income applied to food purchases outside the home, which increased from 11.07 percent in 2007 to 13.95 percent in 2016.[14]

14 Critics argue that it is highly unlikely that the significant gains in average real income growth experienced, particularly during the period 2007–14, did not translate into any meaningful reduction in the share of food expenditures in total household income. They suggest that the explanation could be linked to issues with the INE data.

Figure 9 . Stunting and overweight rates on children under age 5

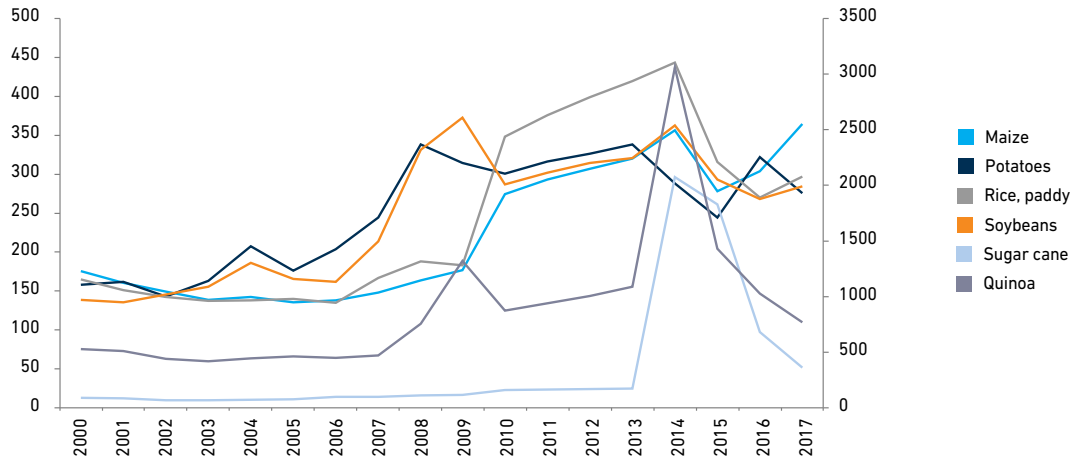


Source: Bolivia: Nutrition country profile. Global Nutrition Report, 2018

Traditional markets remain the main outlet for food purchases in Bolivia. The modernization of traditional markets is a recent development, but cities such as Santa Cruz and La Paz have made very important investments to improve infrastructure in wholesale and large traditional retail markets (*mercados minoristas*). The penetration of supermarkets and modern retail/wholesale outlets has moved at a slower pace in Bolivia than in other LAC countries, but it is picking up quickly, particularly in Santa Cruz. Supermarket expansion is expected to accelerate in the next few decades, influencing food choices and creating opportunities for supply-chain consolidation and modernization, including important investments in improved cold chain and overall agri-logistics and improved food safety. Along with modern food outlets, traditional markets will remain an important avenue for linking agricultural supply with consumer demand and will also continue to play an important social and cultural role, particularly for indigenous communities. Sustained income growth, infrastructure development, increased foreign direct investment, and policy factors can also significantly influence the speed of Bolivia's agri-food transformation.

As these dietary shifts are taking place, Bolivia is experiencing the spectrum of health challenges linked to poor nutrition: hunger (and hidden hunger), malnutrition, and obesity. Bolivia has significantly reduced the number of undernourished people (to 20 percent in 2016 from 33 percent in 2000), but it is also seeing rapid increases in obesity and overweight, which are risk factors for many chronic non-communicable diseases. The trend toward increased obesity and overweight in children and women that is commonly observed in other lower- to upper-middle-income countries is also seen in Bolivia. Between 2003 and 2018, Bolivia achieved a tremendous reduction in stunting among children under age 5—although stunting remains very high in rural areas (24 percent) compared to urban areas (12.2 percent)—but the very same age group now suffers from overweight, which is on the rise in urban and rural settings (Figure 9). The coexistence of wasting, stunting, and overweight among children under age 5 reaches 2.2 percent. Overweight/obesity rates are particularly worrisome in the next highest age bracket (ages 5–19). By 2015, 26.2 percent of boys in this age bracket and 29.9 per-

Figure 10. Producer prices of key agricultural products, US$ per ton



Source: FAOSTAT

Note: Agricultural Producer Prices (APP) are prices received by farmers for their produce at the farm gate (i.e., at the point where the commodity leaves the farm).

cent of girls were overweight, and 9.7 percent of boys and 8.5 percent of girls were obese.

The government is proactively addressing the challenge of obesity and overweight. In 2016, the government released Law N° 775 for the promotion of healthy food habits (Ley de Promocion de la Alimentacion Saludable) to support emerging efforts to enhance the consumption of traditional and highly nutritious foods, which have been underused, sometimes stigmatized as "poor people's food," and neglected, but which are integral to Bolivian culture and traditions.

2.4. Emerging challenges and opportunities

The past decades have been a period of tremendous economic growth and overall prosperity, yet recent estimates suggest that gains in poverty reduction and labor markets weakened during the period from 2014 to 2017. During that period, Bolivia managed to retain dynamic growth rates in the face of international pressures, such as the as the fall in international oil prices, the reduction in other export prices, and the appreciation of the US dollar.

A recent assessment by the World Bank[15] found that although economic growth has remained strong, the impacts of external shocks translated into a growth reduction in average household income during 2014–17—a factor that drove significant poverty reduction in the past. The fall in labor income was not due to a reduction in employment, but instead was due to an increase in employment in non-conventional jobs, particularly self-employment, with lower and decreasing incomes mainly caused by a reduction in labor income. The average household income was offset, in part, by changes in the poverty line linked to lower costs of the basic basket of the poor, especially in rural areas.

In the agricultural sector, leading traditional commodity sectors such as soybeans, and particularly

15 Evaluación de la pobreza en Bolivia: Progreso y desafíos para las políticas sociales y laborales, May, 2019. The World Bank.

non-traditional sectors such as quinoa (with a high participation of small-scale farmers), experienced significant declines in income gains as a result of lower international prices.

At the same time, several products of the food basket (such as potatoes and rice) faced increased price competition from imports, resulting from the depreciation of local currencies against the US dollar in competing countries.

In the face of a challenging external environment, the authorities have been implementing countercyclical policies and an ambitious five-year investment plan—The National Economic and Social Development Plan 2016–2020 (PDES)—approved in early 2016. This plan includes a broad public investment program financed by macro-economic buffers, Central Bank loans, and external financing. The PDES has been supporting growth but is also contributing to fiscal and external current account deficits and foreign reserve losses (IMF 2018a). Experts argue that maintaining macro-economic stability and strengthening competitiveness will be key for sustaining economic and social gains.

The agri-food sector offers major avenues for supporting increased economic diversification and inclusive growth. As noted here, the strong performance of Bolivian agriculture has been key to maintaining the momentum of economic growth over the past two years as exports from the mining/gas sector declined (IMF 2018). But ensuring that such growth translates into wealth gains for hundreds of Bolivian farmers is critical. PDES has very ambitious goals for agriculture: it seeks to support economic diversification, increase value addition and industrialization, and ensure food sovereignty. Its targets are equally ambitious with respect to the expansion of cropped area, annual increases in the volume of agricultural exports and agricultural production, and specific crop production targets for import substitution.[16]

The agriculture and food sectors can make an even greater contribution to addressing Bolivia's key poverty and development challenges if they can become more productive, more competitive, and experience continuous, inclusive, and sustainable growth. Strategies to promote these objectives will be more successful if they are based on a more precise understanding of regional opportunities and challenges related to productivity, competitiveness, and agricultural sector vulnerabilities. The chapters that follow lay the groundwork to develop that understanding.

16 While PDES covers all sectors, the five-year Comprehensive Development Plan for the Agricultural and Rural Sector (PSARDI) adopted in 2017 details the set of policies and targets for the agricultural sector.

3.

Agricultural performance and production systems

Photo: Shutterstock

Table 5. National Wealth Estimates, Bolivia and Lower-Middle-Income Country Average

Total wealth per capita	Bolivia	Average Income Group*	Total natural capital per capita	Bolivia	Average Income Group*
(2014 US dollars)	49,235	25,948	(2014 US dollars)	17,527	6,949
Subsector share	%	%	Subsector share	%	%
Produced capital	13.45 %	25.17 %	Forest	17.79 %	3.49 %
Natural capital	35.59 %	26.78 %	Protected areas	19.87 %	7.19 %
Human capital	50.38 %	50.55 %	Crop and pasture land	43.37 %	61.37 %
Net foreign assets	0.56 %	-2.5%	Subsoil assets	18.95 %	27.97 %

Source: Lange, GM et al (2018)— The Changing Wealth of Nations 2018

3.1. Natural capital to support diversified agriculture in Bolivia

Bolivia's natural capital, represented by its diverse geography and agro-ecological zones, abundant supplies of land and water, and varied climate, provides the basis for its diversified agricultural sector. In 2014, Bolivia's natural capital represented 35.6 percent of the country's total per-capita wealth (Table 5),[17] almost 9 percentage points above the corresponding average share in lower-middle-income countries. Crop and pasture land, in turn, represented 44 percent of the country's natural capital wealth, which corresponds to 13.5 percent of the total national wealth per capita.

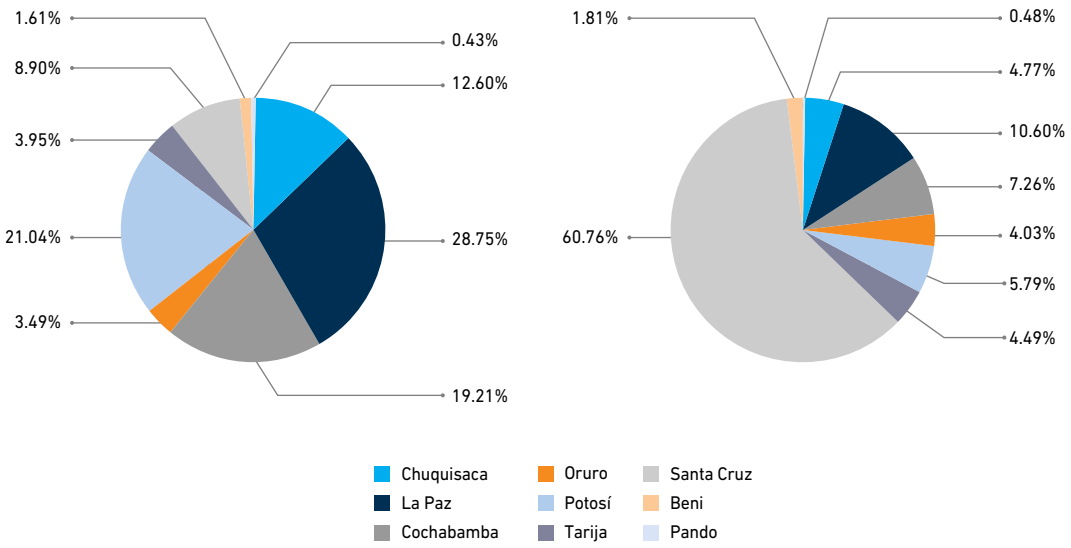
Bolivia's crop and pasture land is a source of agricultural growth, and Bolivia has used it. Between 1950 and 2016, total harvested area increased five-fold, from around 654,000 hectares to more than 3.5 million hectares (INE Statistics). Most of this expansion took place in the lowland areas (including Amazon Region), which accounted for 73.6 percent of the total expansion, followed by the highlands (14.6 percent) and Andean valleys (11.8 percent). Figure 11 shows the distribution of agricultural land across Bolivian departments between 1950 and 2013. The most remarkable development, apart from the increase in total agricultural area reflected in the different sizes of the two pies, is the striking increase in the relative importance of Santa Cruz Department, which had 8.9 of all harvested area in 1950 and 60.7 percent by 2013.

3.2. Patterns in crop and livestock production and value

The production structure in Bolivia has not changed significantly in the last 15 years. The share of the top 10 crops remains the same, estimated at about 80–82 percent of harvested area and of about 87–90 percent of production. The most significant increases occurred in cereal and oilseeds/industrial crops. Oilseeds and industrial crop production increases were driven mostly by sugarcane and soybeans; in 2017, production of these two crops surpassed 11 million tons, roughly five times the total for cereals, which had the second-highest production volume (Table 6). On the other hand, the area planted to cereals has doubled since the early 2000s, growing faster than the area planted to oilseeds and industrial crops. The recent expansion of vegetable crops is also notable; their area has nearly doubled since the early 2000s.

17 National wealth includes produced capital, natural capital, human capital, and net foreign assets. It complements GDP and other macro-economic indicators by measuring changes in a country's underlying asset base.

Figure 11. Harvested area shares, by department. Bolivia, 1950-2013



Source: Calculations based on INE and Census data

Table 7 ranks the main crops by value. The share of the top 10 products increased from 40 percent to 45 percent between 2000 and 2016 (the last year for which data are available). Soybeans, sugarcane, potatoes, and maize continue to be the leading crops, accounting for one-third of the value of agricultural production in 2016. The share of soybeans in total crop value rose from 13 percent in 2000 to 20 percent in 2016. The increasing relevance of sorghum, wheat, and bean production is notable. Sorghum, which ranked 26th in value of production in 2000, had surged to 5th place by 2016, adding nearly 240,000 hectares of harvested area during that period. The value of wheat production tripled during the same period, while the value of dried beans increased seven-fold. Dried beans from Bolivia increasingly supply regional markets, and although the value of bean production is just 0.4 percent of the value of maize production, beans occupy only 19 percent of the land area used in maize production.

Growth in the production value of high-value crops such as nuts (chestnuts and Brazil nuts) and quinoa has been modest. For Brazil nuts, annual average growth was nearly 2 percent during 2000–16; total production value of chestnuts declined during the mid-2000s and has been recovering slowly in recent years. For quinoa, average annual growth in the value of production reached 16 percent during 2010–13 but has been negative since 2014, when international prices collapsed. Crops such as tomatoes and cassava, which ranked high in terms of value in the early 2000s, have been losing share. Area planted to tomatoes has increased only by 1,765 hectares, while cassava (yuca) area increased by roughly 10,000 hectares. Coffee area grew by approximately 3000 hectares during 2000–16, but its total value declined.

The value of livestock production has increased nearly 70 percent since 2000 and was estimated at US$1.6 billion in 2017. The national cattle herd was about 9 million head in 2017, adding about 2.6 million more animals since the early 2000s. Beef production is es-

Table 6. Production volume and area by crop category. Bolivia, 2000-2017.

Crop	Production 2017 (tons)	Δ Production 2000-2017 (Tons)	Production Annual Average Growth Rate (%)	Area 2017 (Ha)	Δ Area 2000-2017 (Ha)	Area Annual Average Growth Rate (%)
Cereals	2,321,408	1,320,336	5.7	1,241,850	616,085	4.9
Forage	486,870	253,124	4.6	120,212	54,650	4.0
Fruits	1,486,203	619,750	3.6	147,557	50,747	2.8
Oilseeds/Industrial	11,177,679	6,386,994	4.3	1,563,302	718,884	4.2
Stimulants	27,876	5,679	1.7	34,187	6,423	1.4
Tubers and Roots	1,419,114	537,464	2.6	225,242	73,387	2.5
Horticulture/ Vegetables	448,579	214,893	4.5	165,853	79,510	4.8

Source: Calculations based on INE data

timated at 260,000 tons per year. The minor livestock species that are important in small-scale agriculture have also increased in number. The llama herd grew by 25 percent over 2000–17 to reach nearly 2.6 million head; sheep numbers increased by 18 percent (7.4 million head in 2017) and alpacas by 23 percent (430,000). Poultry production expanded tremendously, growing by 194 percent between 2000 and 2017.

3.3. Trade trends

The patterns of crop expansion have supported the strong export growth experienced during the past two decades, with increasing concentration of exports on a few products. The share of soybeans and soybean by-products in the total value of Bolivia's exports was estimated at 8 percent in 2007; it rose to 12 percent in 2016 and then declined to 9 percent in 2018. The share of primary agriculture products (excluding soybeans) in the total value of Bolivia exports increased from 4 percent in 2007 to 4.8 percent in 2018. Non-traditional agricultural exports are led by Brazil nuts, quinoa, bananas, chia, and beans, which together represented 87 percent of the total value of agricultural exports in 2018 (excluding soybeans and their by-products).

Agricultural exports and soybean exports contracted during 2014–16, regaining momentum in 2017 and 2018 (Figure 12a) but showing again a contraction in 2019 (Figure 12b), reflecting changes in international prices. For example, soybean prices dropped from US$521 per ton in May 2014 to US$368 in December 2015 and below US$300 most recently. The price of quinoa, in turn, plummeted from US$6.34 per kilogram in 2014 to US$1.66 in 2017, and then improved somewhat to US$2.32 in 2018. Bolivia's main agricultural export partners include Colombia, Peru, Ecuador, Chile, the United States, Germany, Argentina, the United Kingdom, Brazil and Italy.

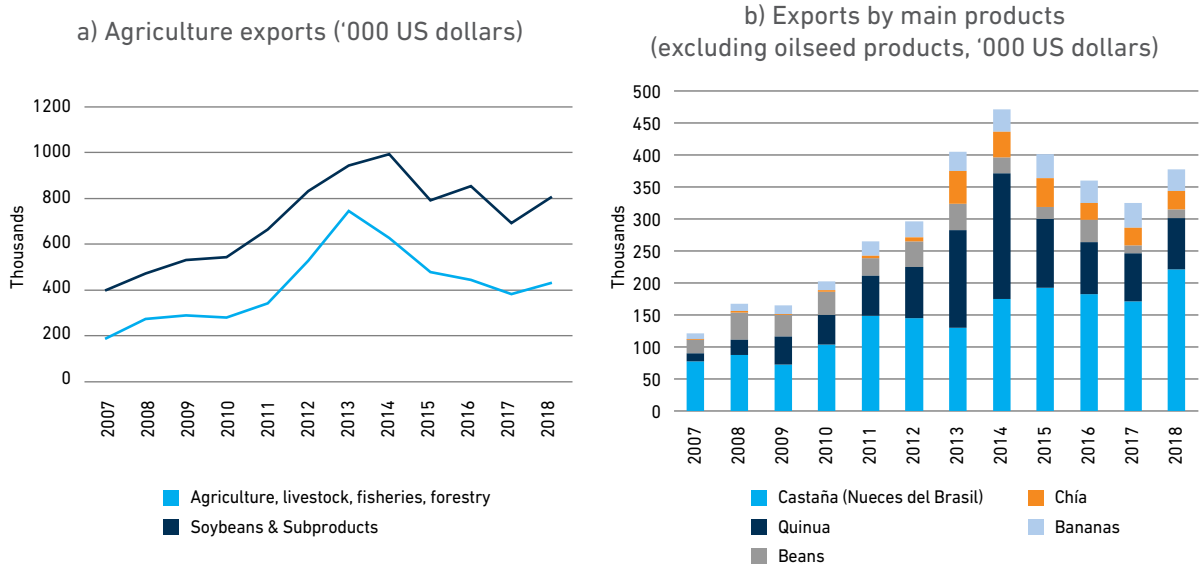
Overall, Bolivia is a net-exporter of agricultural products, and its agricultural trade balance has showed a surplus during 2000–18 (Figure 13). The growth of agricultural imports has been very dynamic, however, increasing on average by 8.5 percent during this period, compared to growth in agricultural and food exports of 8.7 percent. In 2018, the value of Bolivia's

Table 7. Ranking of crops in terms of their share of total agriculture value ('000 dollars, constant 2010). Bolivia, 2000-1016.

Ranking	Crop	2000	Ranking	Crop	2016
1	Soybeans	328,399	1	Soybeans	879,013
2	Potatoes	121,770	3	Potatoes	181,228
3	Sugar cane	118,271	2	Sugar cane	226,930
4	Maize	92,546	4	Maize	133,624
5	Rice, paddy	83,342	6	Rice, paddy	113,408
6	Plantains	78,283	7	Plantains	94,320
7	Bananas	45,603	8	Bananas	84,371
8	Tomatoes	36,117	23	Tomatoes	36,117
9	Cassava	35,754	24	Cassava	35,754
10	Brazil nuts	32,286	14	Brazil nuts	32,286
13	Chestnut	26,752	9	Chestnut	65,957
26	Beans, dry	7,999	10	Beans, dry	56,913
32	Sorghum	14,538	5	Sorghum	128,396
22	Wheat	16,016	12	Wheat	54,631

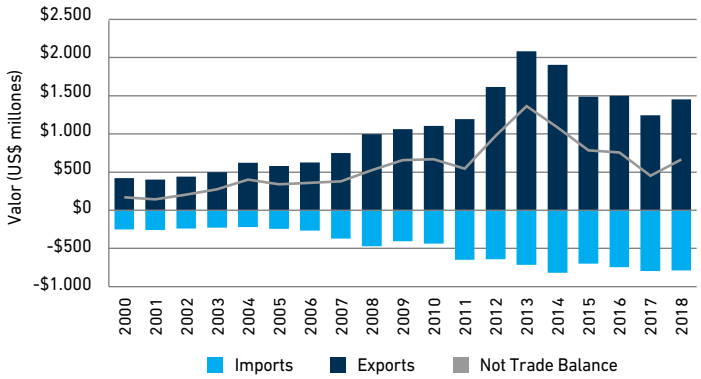
Source: FAOSTAT

Figure 12. Agriculture exports. Bolivia, 2000-2018



Source: Calculations based in INE data

Figure 13: Agricultural trade flows, Bolivia 2000-2018 (US$ '000)[19]



Source: Calculations based on COMTRADE data

agricultural imports reached US$0.78 billion. The top five leading import categories represented 62 percent of the value of imports in 2018 and included edible food preparations; products for the milling industry; cereal preparations; beverages and spirits; and cereals. The category of edible food preparations has doubled in value since 2010, representing 22 percent of the value of agricultural imports in 2018. Fruit imports attained a value US$22.5 million in 2018, representing only 2.8 percent of the value of imports that year, but this category of imports has shown very strong growth (an average annual growth rate of 8.8 percent since 2010). Imports of vegetables showed an increasing trend during 2010–17, with average annual growth of 9 percent over that period and a value of US$4 million in 2017 (which is still less than 1 percent of the total value of imports).[18] The top 10 import partners are Argentina, Brazil, Chile, the United States, Peru, Colombia, Republic of Korea, Paraguay, Mexico, and mainland China.

These developments reflect the trade policy implemented by the Government of Bolivia, which controls exports and imports as part of its objective of achieving food sovereignty (For more details see Chapter 6.3).

3.4. Characterising Bolivia's agriculture

3.4.1. Duality and spatial heterogeneity

Bolivian agriculture has a dual structure in which traditional and commercial agricultural production systems coexist. On the one hand, most agricultural production units—*unidades productivas agropecuarias*, referred to as "UPAs" throughout this report—and the bulk of the rural population form part of the peasant-indigenous economy. Using traditional and only partially mechanized production methods, numerous small-scale and medium-scale farmers produce agricultural products mostly for their own household consumption; with limited access to markets and commercial networks, they produce only a limited surplus for sale in local markets and nearby urban centers. A high number of producers sell their products to intermediaries. Traditional agriculture is characterized by the low availability and quality of productive inputs

18 In 2018 the figures suggest a considerable contraction, with the value of agricultural imports estimated at US$1.7 million.

19 Exports and imports include the categories: animals, vegetables, and processed food.

and resources, which translates into low levels of investment, automation, and innovation, and the pursuit of traditional risk-minimization strategies.

Commercial agroindustry, on the other hand, features a large-scale, specialized production model that makes use of modern production techniques, a predominantly hired labor force, and capital-intensive production practices. Producers enjoy good levels of access to working and financial capital, as well as to technical assistance and information. Well-developed backward and forward linkages make this system highly suitable for the national and export market.

This heterogeneity has a clear spatial component. Producers in the western and Andean areas of Bolivia tend to follow a more traditional agricultural model dominated by subsistence farming, but moving eastward toward the inter-Andean valleys, mixed production models are more common. In these mixed models, traditional farming systems on the slopes coexist with modest mechanization and modern technology in the plains, and relatively sophisticated rural societies enjoy moderate market access. Eastern Bolivia is characterized by the prevalence of modern commercial agribusiness and extensive production systems.

The segmentation of agricultural production systems across the country calls for a regional analysis that brings up the diversity in Bolivia's agriculture, addressing the key challenges and opportunities faced by the sector across the different macro-regions.

3.4.2. Production trends and systems in the macro-regions

Table 8a below highlights the relevance of agricultural activities in Bolivia's departments to the national and local economy. Santa Cruz, Cochabamba, and La Paz are highly diversified economies; together, they contribute 70 percent of the value of Bolivia's agricultural output. In departments such as Beni and Pando, however, agriculture's largest contribution is to the local economy.

Producers in different regions specialize in very different sets of crops. Annex 1 displays the average area harvested per crop in each macro-region. Table 8b presents the cropping structure for 2014/15–2016/17, based on the area cultivated in a representative department for each macro-region: Santa Cruz (Lowlands), Cochabamba (Sub-Andean), Potosí (Highlands), and Pando (Amazon). Even though potatoes are a major crop in both Cochabamba and Potosí, and fruit production is prominent in Cochabamba and Pando, the four departments actually present very different profiles of crop specialization. For example, Santa Cruz produces a vast range of crops, but soybeans predominate by far, occupying 52 percent of cultivated area. In turn, Cochabamba (Sub-Andean Region) and Pando (Amazon Region) show a more polarized structure; agriculture in Cochabamba emphasizes fruit, potatoes, and maize (jointly accounting for approximately 65 percent of cultivated land), and Pando emphasizes fruit, maize, cassava, and rice (86 percent of the cultivated land). Potosí, on the other hand, reveals less emphatic crop preferences, although potatoes and quinoa jointly account for 47 percent of the cultivated area.

Triangulating the information of Table 8b with Figure 14, which displays the distribution of producers by the main crops in the macro-regions, sheds light on the scale of production for various crops. For example, despite its unquestionable prevalence in terms of land use, soybean is grown by only 8 percent of the UPAs in the Lowlands Region, which is indicative of large-scale, commercial agriculture. In the same region, on the other end of the spectrum, maize is the most frequently harvested crop (grown by one-third of UPAs), but it is grown on less than 10 percent of the cultivated area. In contrast, in the Sub-Andean and Highlands Regions, the share of UPAs growing a crop matches the share of cultivated area for that crop quite closely. In the Sub-Andean Region, potato

Table 8. Ranking of crops in terms of their share of total agriculture value ('000 dollars, constant 2010). Bolivia, 2000-1016

a) Share of AG in total GDP and Department GDP

Department	Agr share of total GDP (%)	Ag share of Department's GDP (%)
Beni	6.9	27.9
Chuquisaca	6.8	15.2
Cochabamba	13.4	9.6
La Paz	17.4	7.0
Oruro	2.2	5.1
Pando	2.2	26.9
Potosi	5.5	10.0
Santa Cruz	41.0	15.8
Tarija	4.7	6.5

b) Percentage of planted area by major crops in select departments, average 2014/15–2016/17 (%)

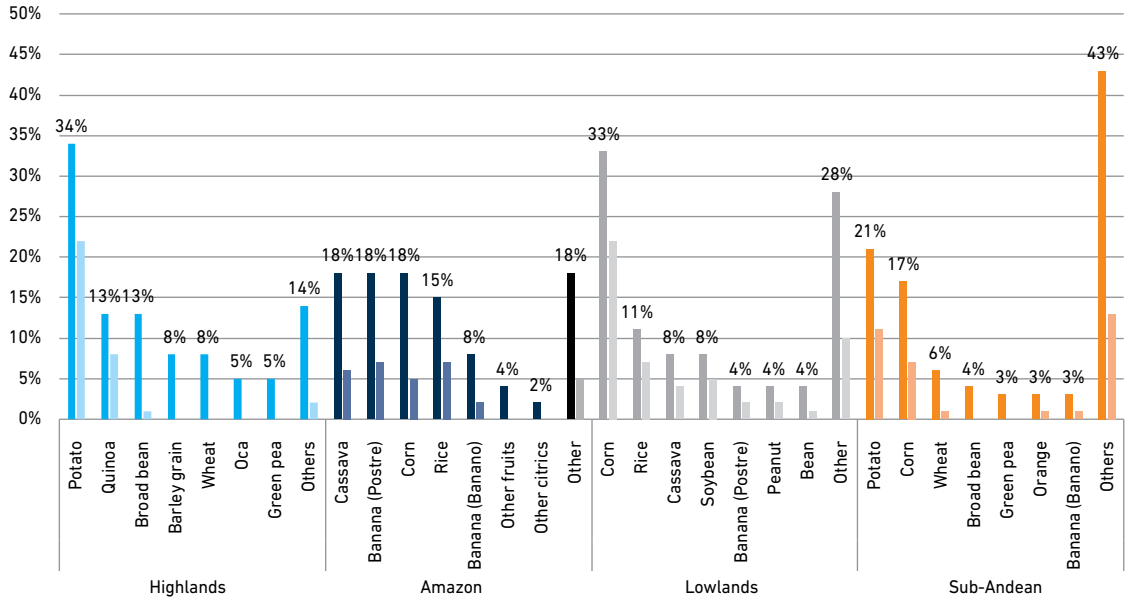
Crop	Lowlands: Santa Cruz	Sub-Andean Cochabamba	Highlands: Potosi	Amazon: Pando
Barley			10.97	
Broad bean		1.97	7.02	
Cassava				18.12
Fruit		28.22		29.15
Maize	9.11	17.28	12.28	22.75
Oats		2.86		
Peas		2.19		
Potatoes		20.46	19.16	
Quinoa			28.17	
Rice	5.11	3.42		17.60
Sorghum	11.27			
Soybean	52.14			
Sugarcane	5.45			1.05
Sunflower	4.70			
Wheat	5.66	9.58	11.42	
Total area (ha)	2,478,744	190,897	157,088	12,859

Source: Calculations based on INE data

and maize production are prevalent (grown by 21 and 17 percent of UPAs, respectively), but the very substantial diversification of production is reflected in the sizeable percentage of producers who grow "other" crops. Agriculture in the Highlands Region focuses on potatoes and quinoa. The crop pattern in the Amazon Region is also consistent with shares of cultivated area; cassava and maize are among the crops grown by large numbers of producers, and the share of producers growing various types of fruit is high.

Differences in the scale of production across macro-regions are even more apparent from the distribution of farm size in each region (Figure 15). In the Highlands Region, for instance, 60 percent of all farms are smaller than 1 hectare, and a staggering 97 percent of UPAs are smaller than 10 hectares. The situation is quite similar in the Sub-Andean and Amazon Regions, even though UPAs of less than 1 hectare are not quite as dominant, but in any case, average farm size does not exceed 3 hectares in any of these regions: it 1.9 hectares in the Highlands, 2.3 hectares in the Sub-Andean Region, and 2.6 hectares in the Amazon Region. The average farm size in the Lowlands Region, at 44 hectares, reflects the more commercial nature of agriculture there. Only 27 per-

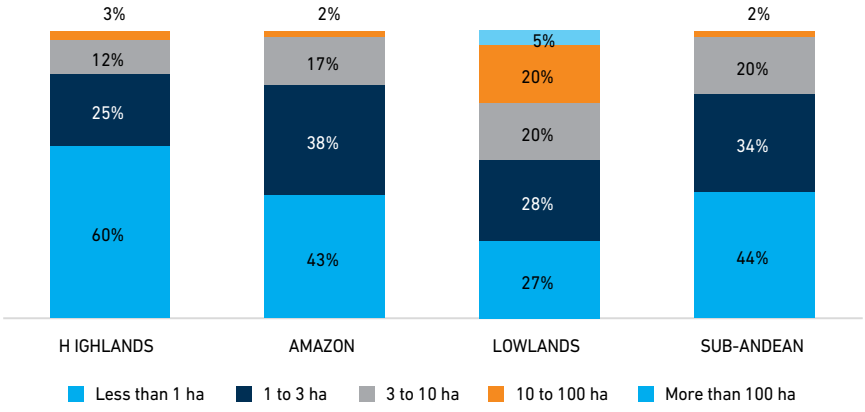
Figure 14. Main crops by macro-region, based on the number of producers. Bolivia, 2015



Note: Light bars: % of total productive units that produce the crop; darker bars: % of total productive units for which the crop represents 50% or more of total GDP

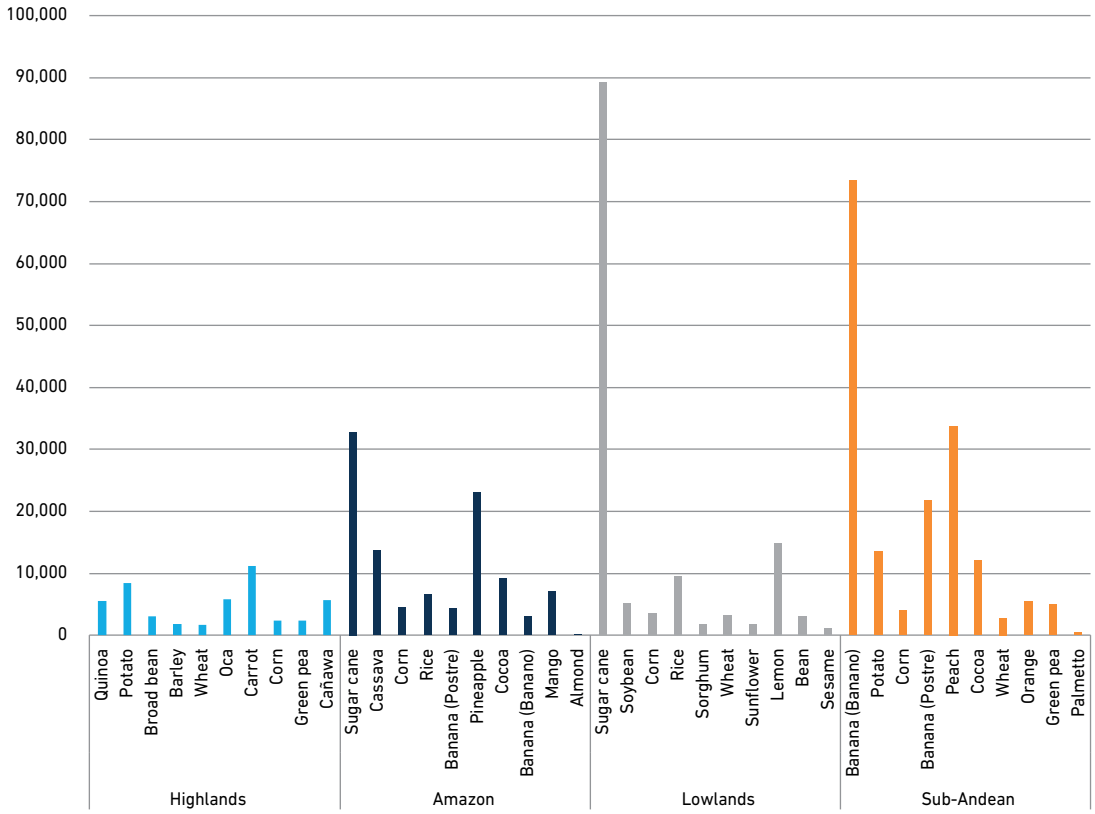
Source: ENA 2015

Figure 15. Distribution of UPAs by size (%)



Source: ENA 2015

Figure 16. GDP of major crops by Macro-region (Bs$/Ha). Bolivia, 2015



Source: ENA, 2015

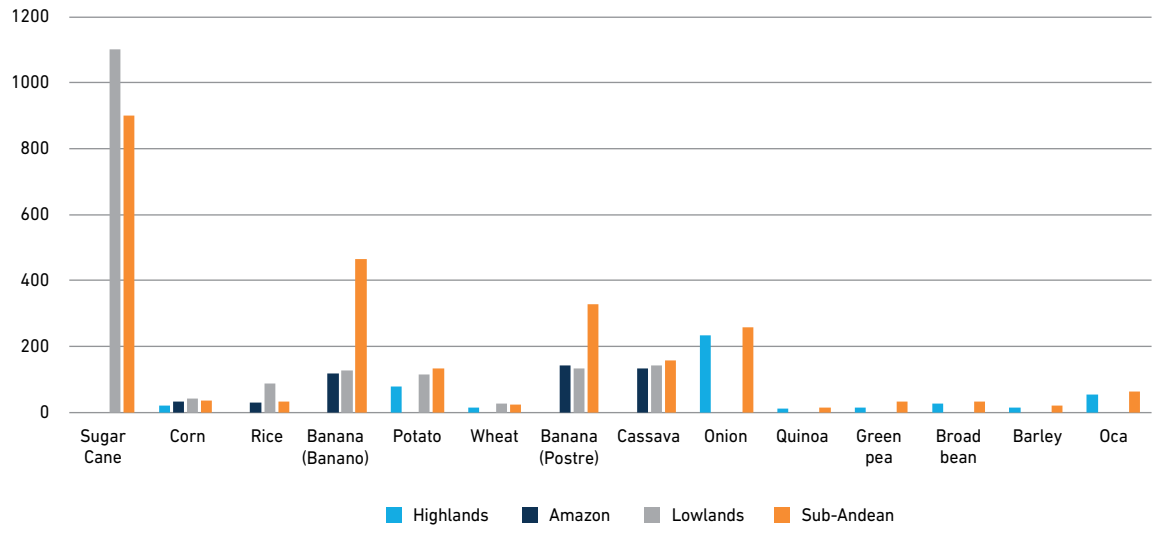
cent of farms in the Lowlands Region are smaller than 1 hectare; 25 percent surpass 10 hectares, and 20 percent exceed 100 hectares.

The East-West farm-size divide seems to extend to land quality as well, with levels of soil erosion worsening toward western Bolivia. Moderate levels of erosion affect more than half of the land in the departments in the Highlands Region like Potosí and Oruro, which also experience severe levels of erosion, in which about 10 percent of soil is eroded. Erosion is caused mainly by water and wind, especially in areas where slopes are steep and vegetative cover is scarce.

Regional disparities in the value of production are shown in Figure 16. Although sugarcane appears to be much more valuable than most other crops in the figure, its value is also clearly greater in the Lowlands Region than in the Amazon Region. Similarly, the substantial diversification of production in the Sub-Andean Region seems to include the production of higher-value crops such as bananas and peaches. In contrast, GPVs per hectare are minimal for all crops in the Highlands Region, including quinoa.

Just as cropping patterns vary widely across macro-regions, so do crop yields (Figure 17). Although yields of crops such as sugarcane and plantain appear high compared to those of other crops grown in Bolivia, in general the yields of practically all crops grown in Bolivia are quite low compared to yields in

Figure 17. Yields of main crops by Macro-regions (Quintals per Ha)



Source: ENA, 2015

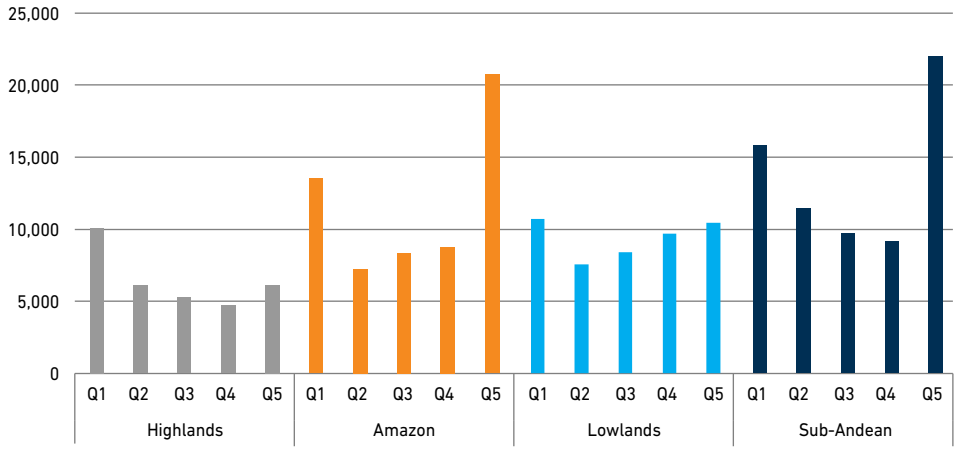
other countries. For example, FAOSTAT data show that the Bolivian sugarcane yield is similar to yields obtained in Argentina, Uruguay, and Paraguay but substantially lower than yields in Brazil (40 percent higher), Colombia (65 percent higher), or Peru (130 percent higher). Banana yields in Colombia, Ecuador, and Peru are 2–3 times higher than banana yields in Bolivia. Similar discrepancies are seen in other important crops such as potatoes and soybeans, although they are more pronounced in soybeans. Compared to the average potato yield in Bolivia, the potato yield is 2 times higher in Ecuador, 2.4 times higher in Peru, 3 times higher in Colombia, and almost 5 times higher in Brazil. But these are minor differences when compared with the yield differentials for soybeans. Argentina and Brazil, soybean production powerhouses, have average soybean yields that are 30–40 percent higher than those in Bolivia.

Figure 18 displays output value per hectare by farm-size class (the number of UPAs in each macro-region was divided into quintiles based on farm size). In the Amazon and Sub-Andean Regions, it is the smallest and largest farms that generate the highest output value per hectare. This result suggests what the literature refers to as a "U-shaped relationship" between profitability and farm size. This relationship is not seen in the Lowland and Highlands Regions, although in the Highlands Region the smallest farms have the highest output value.

Another relevant aspect of regional production patterns to analyze is the labor productivity of the main crops. Figure 19 displays the ratio of agricultural GDP to the number of days worked per year by family and hired labor in each UPA. Labor productivity was highest in the Lowlands Region, even when only family or hired labor is considered. The Highlands Region has the lowest labor productivity.[20]

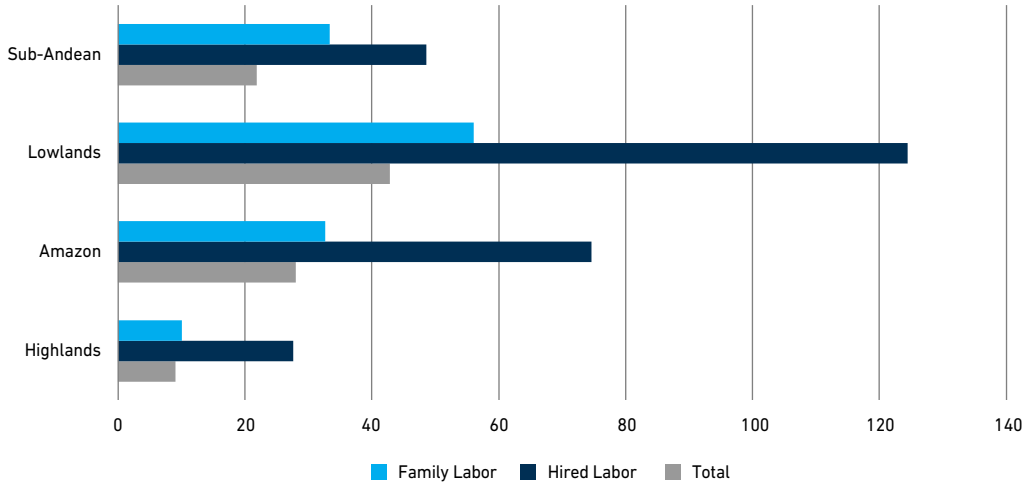
20 This higher labor productivity may reflect the fact that most crops in the Lowlands Region are less labor-intensive to produce and have higher yields. In addition to these considerations, it is possible that some of the difference in labor

Figure 18. GDP (Bs$/Ha) according to farm-size, by Macro-regions



Source: ENA 2015

Figure 19. Output per worker Bs/day/UPA (annual average per UPA)

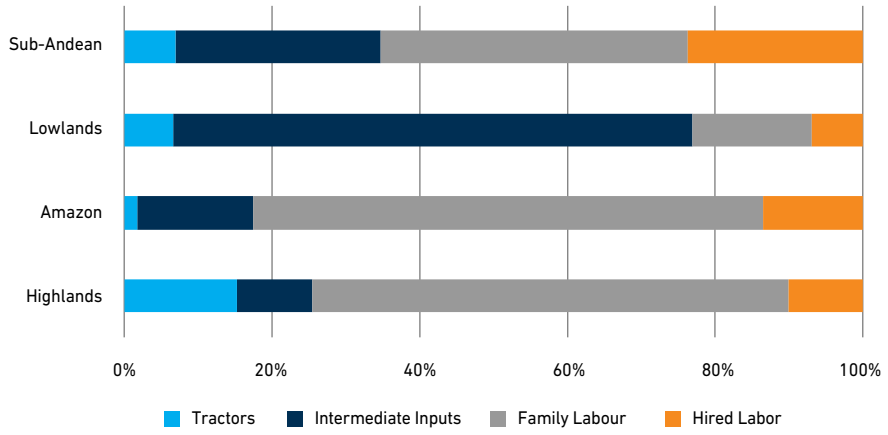


Source: Calculations based on ENA 2015

A more complete view of the use of factors of production, including labor, is presented in Figure 20. This figure shows the percentage distribution of the inputs used by UPAs, including intermediate inputs, capital (tractors), and hired and family labor. The Lowlands Region differs from the Amazon and Highlands Region in the greater relative use of intermediate inputs with respect to the other factors of production. The greater preference for intermediate inputs in the Lowlands Region could be related to the higher prof-

productivity between the Lowlands and other regions is the result of higher levels of training, knowledge, and information in the lowland workforce. However, it could also be due to the intensive use (or higher quality) of other inputs (beyond land and labor).

Figure 20. Expenditure share in inputs (Percentual distribution by Macro-region)



Source: ENA 2015

itability and yields of crops gown there. In the Amazon and Highlands Regions the main factor of production is family labor. Spending on inputs is most evenly balanced in Sub-Andean Region.

The Lowlands Region is also the national leader in use of certified seed, with the Santa Cruz Department alone accounting for 83.4 percent of certified seed use in Bolivia (Annex 1). The overwhelming majority of certified seed used in Santa Cruz is soybean seed, reflecting the region's specialization in this crop. Producers in Santa Cruz Department also use high level of certified wheat, maize, and rice seed. Elsewhere in the country, the use of certified seed is most common in potato (Cochabamba, La Paz, Oruro, Potosí, and Tarija), rice (Beni), and maize (Chuquisaca) production.

Irrigation is concentrated in the Sub-Andean Region (Annex 1). The Highlands Region has a higher-than-average presence of small and micro irrigation systems, while the Lowlands Region has a proportionally much higher share of medium and large irrigation systems. Most irrigation systems in the country (81 percent) are the traditional flood and gravity type, which contributes to low agricultural productivity and progressive soil erosion. Only 5 percent of all irrigation systems use modern technology.

Fertilizer use is extremely low in Bolivia, especially compared to other countries in the region (Annex 1). Mechanization could also improve, as suggested by estimates of the use of various types of farm machinery and tools in 2013–14 (Annex 1).

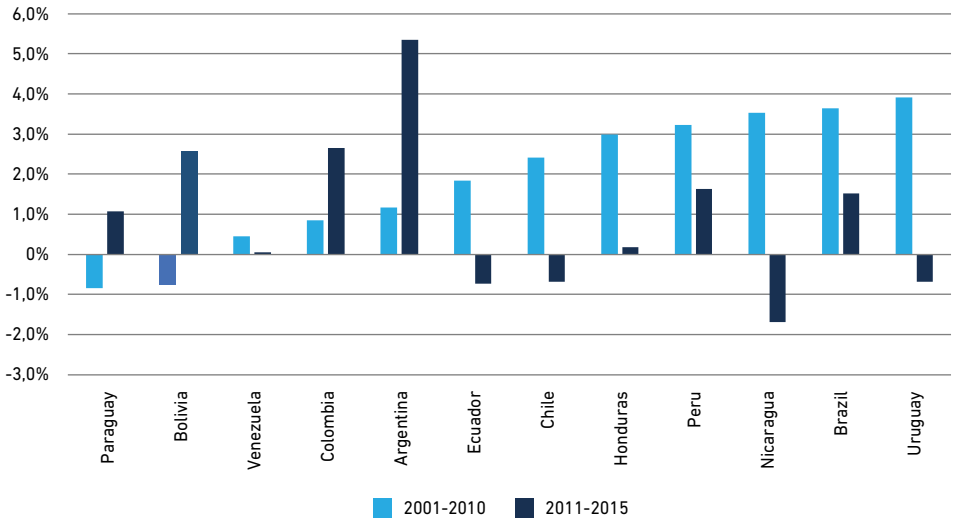
Against this review of the major distinguishing features of agriculture in the macro-regions, the chapter that follows presents a detailed analysis of patterns of productivity for the four macro-regions, major crops, and farm-size categories. The results offer insight into the opportunities for improving the efficiency of agricultural production in Bolivia's highly diverse agricultural landscape.

4.

Productivity and Efficiency of Agriculture in Bolivia

Photo: Shutterstock

Figure 21. Agricultural TFP growth, 2001–15 (%)



Source: USDA, 2018

4.1. Bringing the productivity and efficiency picture into focus

The agricultural sector is making and can make an even higher contribution to economic development and poverty reduction in Bolivia if it gives high priority to growth in productivity. As Hayami and Ruttan (1971, 1985) point out, the success of agriculture has more to do with increases in productivity than with using more inputs or cultivating more land.

The previous chapters discussed the components of agricultural growth in Bolivia related to area expansion and input intensification. This chapter seeks to understand the levels of efficiency in the use of agriculture inputs as a key determinant of long-term productivity gains. A method that is commonly used in this kind of assessment is the estimation of Total Factor Productivity (TFP). Estimations of TFP are often provided at an aggregated level for the overall agricultural sector. Those estimates indicate that productivity growth in Bolivia has been modest over the last two decades and that it has been mainly the result of technological change rather than because of increased technical efficiency or managerial capacity (Pfeiffer 2003; Ávila et al. 2010; Pratt et al. 2015; Trindade and Fulginiti 2015). However, as illustrated in Figure 21, TPF in Bolivia displays two very distinct patterns. The first pattern is negative growth during the period 2001–10 (–0.8 percent), making Bolivia one of the worst performers in the LAC Region. The second is a more positive growth rate during the period 2011–15 (2.6 percent), when Bolivia was surpassed only by Colombia and Argentina.

Despite positive TFP growth, the productivity of land and labor remains low in Bolivia compared to other countries in the region (Table 9). Land productivity is four times higher in Colombia, three times higher in Ecuador, and two times higher in Peru. Labor productivity is three times higher in Mexico, Ecuador, and Paraguay; it is two times higher in Colombia, and higher by half in Peru.

To date, the only measures of the productivity and technical efficiency of Bolivian agriculture come from

Table 9. Land and labor productivity in selected LA countries

Country	Land Productivity		Labor Productivity	
	Output per hectare (2004-2006 USD$/Ha) Year 2015	Av. Annual Growth 2004-2015 (%)	Output per worker (2004-2006 USD$/worker) Year 2015	Av. Annual Growth 2004-2015 (%)
Mexico	1435	2,11	5289	3,18
Colombia	3247	1,82	4609	2,44
Ecuador	2435	2,21	5141	2,25
Peru	1650	3,14	2648	3,40
Venezuela	1758	1,57	10 510	3,30
Brazil	1736	2,26	16 631	6,12
Argentina	1125	0,63	35 954	2,86
Chile	3841	1,63	8914	1,45
Paraguay	1133	2,14	6943	3,81
Uruguay	1552	-1,93	23 953	2,85
Honduras	1426	1,52	3302	2,01
Nicaragua	855	4,42	4882	3,26
Bolivia	751	2,64	1909	1,76

Source: Calculations based on USDA 2018 data

studies at the national level. As indicated in the overview of macro-regions in Chapter 3, however, Bolivian producers operate in extremely diverse agricultural settings. The regions differ substantially in the kinds of production systems they can support, the characteristics of producers, and yields of the main crops.

Considering these marked differences, more granular information on productivity and efficiency across macro-regions, farm types, and crops could provide greater insight into opportunities for tapping new sources of productivity growth in Bolivian agriculture. This chapter attempts to narrow this knowledge gap. It describes results of a more detailed assessment of technical efficiency across Bolivian's macro-regions, farm sizes, and crops, based on stochastic frontier and meta-frontier analyses, and explores the implications for policies designed to increase productivity and competitiveness. The analyses also provides important insights for policy analysists on the information gaps that need to be addressed to generate estimates of productivity at aggregate and more granular levels and make it possible to monitor improvement over time.

4.2. Productivity and technical efficiency: main concepts

The traditional measure of agricultural productivity—output per hectare (volume or value per hectare)—is incomplete, since it does not consider the use of other inputs that may contribute to productivity, such as fertilizer, labor, pesticides, machinery, and so on. *Total factor productivity (TFP)* is a more complete measure of productivity that accounts for all inputs used in production and compares them with the total amount

of output (in this case, crop and livestock products). TFP is defined as the ratio of total output (Y) to total inputs (X). If total output is growing faster than total inputs, TFP is said to be improving—in other words, productivity is growing.

Since TFP is measured as a residual, it is important to recognize that spatial and temporal differences in TFP can be caused by a wide range of factors. Spatial differences in TFP are commonly the result of structural factors, such as variability in climate, topography, and soil quality. Spatial differences in TFP can also result from locational differences in access to finance and to the capital embodied in infrastructure investments. By contrast, temporal differences in TFP are usually caused by other factors, such as changes occurring over time in the mix of crops, adoption of new technology, reductions in transaction costs due to the appearance of new information and communication technology (ICT), or improved connectivity to markets arising from the construction of new transportation infrastructure. Other factors that could contribute to changes over time in TFP could be more difficult to measure, such as improved access to financial assets, the level of entrepreneurial ability within a region, and the attractiveness of a region to new entrepreneurs. In summary, TFP is a measure explained both by the context in which farmers operate and by their own decisions and productive abilities.

Technical efficiency is closely related to the ability of firms to achieve the optimal combination and best use of inputs to produce the best results with a given technology. Therefore, unlike TFP measures, technical efficiency has to do with the productivity component that is largely under the farmer's control—the portion of TFP explained by decisions and productive ability discussed in the previous paragraph.

Together, TFP and technical efficiency are important measures for understanding the varied performance of agriculture in Bolivia's diverse agricultural landscape. TFP measures make it possible to compare productivity levels among different groups and over time, while the analysis of efficiency helps to identify the determinants of productivity at the farm level, which is useful information for defining the scope of specific policies to support productivity.

The relationship between productivity and efficiency is depicted in Figure 22, which shows two groups of production units with different levels of productivity (TFP). In this example, group 2 (G2) has the highest productivity, and group 1 has the lowest. Productivity is the output/input ratio (Y/X, and technical (in)efficiency can be understood as the difference in productivity of one production unit (any of the blue or red dots) compared to the more productive units (located at the frontier), depending on the context or group in which the operation takes place.

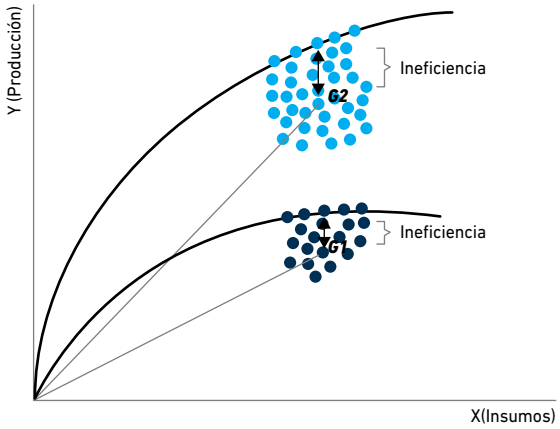
Data to carry out a disaggregated TFP analysis for agriculture in Bolivia are not available, so the productivity analysis described here focuses on understanding technical efficiency through stochastic frontier and meta-frontier analyses, for which data are available. Annex 2 explains the data requirements and data sources for TFP and those used to carry out the stochastic frontier analyses presented here.

4.3. Methodology and variables

4.3.1. Stochastic frontier analysis and meta-frontier analysis

Stochastic frontier analysis (SFA) is used to estimate a production frontier, which represents the current state of technology in a certain industry or sector. The frontier also defines the maximum potential or optimum level of production of the industry. Firms or companies operate on the frontier if they are technically efficient, and below the frontier if they are not. The frontier is considered stochastic because the deviations from the frontier include a component that represents random shocks affecting the production

Figure 22. Productivity and efficiency: illustration of concepts



Source: Author's elaboration

process and another component with a specific distribution function representing technical inefficiency.

One disadvantage of standard stochastic frontier models is that it is not possible to compare the technical efficiency of producers using different technologies, since they do not operate under the same production frontier. Spatial differences in temperature, rainfall, soil characteristics, and other production factors determine the input-output combinations that are possible for each region, and these combinations result in different production frontiers. Bolivian producers from different macro-regions (and even within the same macro-region) inevitably use different technologies and production systems to accommodate their divergent circumstances. To get around this difficulty, a stochastic *meta-frontier efficiency analysis (MFE)* is used to calculate efficiency measures that allow comparisons between groups with different technologies (see Annex 2 for details on the methodology and data sources).

The overall analysis had several components:

- Stochastic frontier analysis to identify the determinants of agricultural efficiency in each macro-region (Sub-Andean, Highlands, Lowlands, and Amazon).
- Stochastic meta-frontier analysis to understand the differences in efficiency levels and technology gaps across regions.
- Stochastic meta-frontier analysis of farms of different sizes (land area) producing four crops of national importance—soybeans, maize, rice (paddy), and potatoes—to explore the relationship between the size of the UPA and meta-efficiency in the selected crops.
- Stochastic meta-frontier analysis of producers located in different macro-regions who grow the same crop, to explore patterns of meta-efficiency.

The next section describes the main variables used to characterize agriculture in the macro-regions. The remainder of this chapter discusses the analysis and the results.

4.3.2. Variables used in the analysis

The sample of agricultural producers for each macro-region (Table 10) comes from the National Agricultural Survey (ENA) 2015. A significant percentage of observations come from the Sub-Andean Region (49 percent). Table 11 presents descriptive statistics on the main variables used in the analysis.

Some aspects of the data should be noted. A UPA in the Lowlands Region has, on average, an annual gross production value (GPV) of 106,379 Bolivian bolivianos (Bs), which is more than twice the national average, almost four times the average of the Sub-Andean Region, five times the average of the Amazon Region, and almost ten times the average of the Highlands Region. These figures partly reflect differences in harvested area among regions—the trend for this variable resembles the trend in average GPV—which reflect the high degree of land fragmentation in the Highlands (also in the Sub-Andean and Amazon Regions) and the scope for extensive land use in the Lowlands.

Table 10. Sample Size: ENA 2015

Macro-Region	Number of observations	%
Highlands	1917	18 %
Amazon	534	5 %
Lowlands	2886	28 %
Sub-Andean	5088	49 %
Total	**10 425**	**100 %**

Source: Author's elaboration

The analysis includes a variable on the use of labor, both family and hired labor.[21] Family labor accounts for more than 85 percent of the value of agricultural labor in the Highlands and Amazon Regions, 75 percent in the Lowlands, and 64 percent in the Sub-Andean Region. Although there are observable differences in the value of family and hired labor, they are small when compared to the observable differences in the cost of the other production inputs.

The average expenditure on intermediate inputs is highest in the Sub-Andean Region; it is slightly higher than the average input expenditure in the Lowlands, even though the average GPV in the Sub-Andean Region is much lower. It may be that Sub-Andean farmers are producing particularly input-intensive crops such as potatoes, fruit, vegetables, or grapes. The Highlands Region has the lowest average expenditure on intermediate inputs, corresponding to one-third of the national average.

As expected, only 3 percent of UPAs in the Amazon Region use tractors, whereas more than 25 percent of producers in the other regions use them. The Lowlands Region uses the most tractor energy.[22] The relatively high use of tractors in the Highlands probably reflects the large expansion of quinoa production and the introduction of mechanization that occurred early in the 2010s.

These data alone provide relatively little insight into the comparative efficiency or productivity of agriculture in the four macro-regions. Clearly the average producer in the Lowlands has the highest GPV and the average producer in the Highlands has the lowest, and the regions where production is highest are the

21 From the data available on the numbers and daily wages of permanent and temporary workers, it was possible to approximate the value of hired labor. The value of family labor was estimated by calculating the average daily wages at the macro-regional level and using data on the number of household members who reported agriculture-based work.

22 The indicator "intensity of tractor use," which is used in the stochastic frontier analysis, expresses energy use in terms of horsepower. Data for this indicator are based on the type of tractor used by each UPA and the reported energy capacity (horsepower). A comparison of data from the Agricultural Census 2013 and the ENA 2008 showed consistent findings on the levels of tractor use in the different macro-regions. In all cases, tractor use is highest in the Lowlands and Highlands (40–50 percent of UPAs), followed by the Sub-Andean Region and, at a considerable distance, the Amazon Region.

Table 11. Descriptive statistics of the main variables used in the analysis [Average per Agricultural Production Unit-UPA]

	Highlands	Amazon	Lowlands	Sub-Andean	Bolivia
Gross production value (Bs-Bolivianos)	11 923	21 200	106 379	27 213	45 123
Harvested area (ha)	1,9	2,5	9,4	2,3	4,1
Labor value (Bs)	28 135	32 646	30 436	36 457	33 113
Family labor value (Bs)	24 380	27 626	22 896	23 151	23 537
Hired labor value (Bs)	3755	5020	7540	13 306	9576
Expenditure on intermediate inputs (Bs)	3883	6355	14 424	15 556	12 618
Expenditure on seeds (Bs)	1716	6242	8521	12 061	8900
Expenditure on organic fertilizer (Bs)	1726	55	397	1556	1204
Expenditure on pesticides (Bs) [a]	308	0	62	289	217
Expenditure on chemical fertilizer (Bs)	17	8	574	597	453
Expenditure on insecticides (Bs)	58	15	2492	470	908
Expenditure on fungicides (Bs)	26	13	523	243	265
Expenditure on herbicides (Bs)	32	22	1855	341	670
% using tractor	48 %	3 %	41 %	28 %	34 %
Energy used on tractor (HP)	35,8	4	42,2	24	30

Source: ENA (2015) and author's elaboration

a The category "pesticides" is understood in ENA as "organic pesticides."

regions with the highest investment in intermediate inputs or the largest production area. It could well be the case that a higher level of production is the result of using more inputs or more land, and not necessarily the result of any higher efficiencies in the use of these production factors.

An SFA and MFE can provide information to make more reliable inferences about the productive efficiency of the different macro-regions and types of producer. The additional variables used for the SFA and MFE analyses are presented in Table 12. These variables were selected from a wider set of variables because they showed the greatest consistency in the regressions performed to develop a robust specification of the model. Unfortunately, critical variables such as distance to the closest city or level of education were not available for the analysis.

What is noteworthy about the variables that are considered to contribute to inefficiency? One outstanding feature of the data in Table 12 above is the low level of collective action through participation in producer organizations. The Lowlands Region has the most producers who participate in an organization (14.4 percent), and the Amazon Region has the fewest (7.1 percent). Access to credit is also low throughout Bolivia, particularly in the Highlands, where only 6.3 percent of producers said they had obtained some type of credit during the last 12 months. Most producers reported receiving information on climate or weather events important for agriculture, with the lowest percentage in the Highlands. At the same time, access

Table 12. Descriptive: Determinants of inefficiency

	Highlands	Amazon	Lowlands	Sub-Andean	Bolivia
Female household head (%)	13,20 %	10,60 %	11,60 %	12,70 %	12,40 %
Membership in organization (%)	11,90 %	7,10 %	14,40 %	11,00 %	11,90 %
Access to credit (%)	6,30 %	8,00 %	18,90 %	15,30 %	14,20 %
Average household size	3,63	4,51	4,2	3,87	3,94
Access to telephony (mobile phone and/or landline) (%)	35 %	34 %	50 %	43 %	43 %
Average agricultural landholding	1,9	2,5	9,4	2,3	4,1
Information received on climatic events in the agricultural sector (%)	65 %	72 %	72 %	73 %	71 %
Access to irrigation (%)	29 %	5 %	7 %	33 %	24 %

Source: Author's elaboration

Table 13. Determinants of meta-technology efficiency

	Highlands	Amazon	Lowlands	Sub-Andean	Bolivia
Altitude (masl)	2855	1241	1706	2284	2184
Average slope (%)	42,2	31,2	45,4	37,5	40,2
Average precipitation (mm)	70,7	113,2	99,5	84,2	87,2
Average temperature (°C)	15,6	21,2	19,7	17,2	17,8

Source: Author's elaboration

to a telephone (landline or mobile phone) is still relatively low at the national level (43 percent), although 50 percent of producers in the Lowlands Region had access. The percentage of households headed by females was slightly higher in the Highlands and the Sub-Andean Region, although it does not exceed 15 percent in any region.

A number of geographical and climate variables influence the meta-frontier for technology efficiency (Table 13). As discussed, these variables are likely to explain some of the differences in use of agricultural technology in each region.

4.4. Analyzing differences in technical efficiency and meta-technical efficiency by macro-region, major crops and farm size

4.4.1. Stochastic frontier analysis by macro-region

Stochastic frontier models were estimated for each macro-region, based on a Cobb-Douglas production function in which the dependent variable is the GPV at the producer level (in log), and the independent variables are harvested area and the expenditure on inputs (labor, intermediate inputs, machinery, in logs). Table 14 below shows the results (specifically,

Table 14. Elasticities and results of the stochastic frontier estimation by region

Results of the stochastic frontier estimation (Dependent variable: Log of gross agricultural production value)				
Independent variables	Highlands	Amazon	Lowlands	Sub-Andean
Log (Inputs)	0,2699***	0,1741***	0,2083***	0,3242***
	(0,0184)	(0,0318)	(0,0169)	(0,0102)
Log (Labor)	0,0592*	0,0173	0,1148***	0,0909***
	(0,0312)	(0,0291)	(0,0205)	(0,0178)
Log (Land)	0,5811***	0,7168***	0,6574***	0,5242***
	(0,0203)	(0,0628)	(0,0270)	(0,0141)
Log (Capital)	-0,1661*	0,7291**	0,2918***	0,0169
	(0,0892)	(0,3676)	(0,0686)	(0,0600)
Returns to scale	0,74	1,64	1,27	0,96
Observations	1889	510	2698	5045
Chi-square	2274,6	334,0	1983,1	4429,2
Log Likelihood	-2437	-737	-4170	-7345
σ_v	0,689	0,698	1,050	0,905
Prob. > chi2	0,0000	0,0000	0,0000	0,0000

Source: Authors elaboration based on ENA (2015) and other sources

the average elasticities of the production factors in each macro-region).

The estimated elasticities of all inputs exhibit the expected sign.[23] The Sub-Andean, Highlands, and Lowlands Regions exhibit the highest elasticity in the value of production with respect to changes in the mix of intermediate inputs, implying that producers in those macro-regions have greater flexibility to increase production by changing the mix of inputs. By contrast, in the Amazon Region the value of production is much less sensitive to changes in the mix of inputs. As expected, in all macro-regions the value of production is most sensitive to changes in land: the elasticity of production with respect to land ranges from 0. 52 to 0.72.

The results reveal important differences across macro-regions in the elasticity of the value of production with respect to changes in farm labor. For instance, the Lowlands Region exhibits an elasticity value that is more than twice the value observed in the Highlands, indicating that an increase in the number of workers would be more effective in raising the value of production in the Lowlands Region than in the Highlands. Farms in the Highlands are small and rely heavily on the use of family labor, whereas Lowland farms are bigger and labor use per unit of land is relatively low.

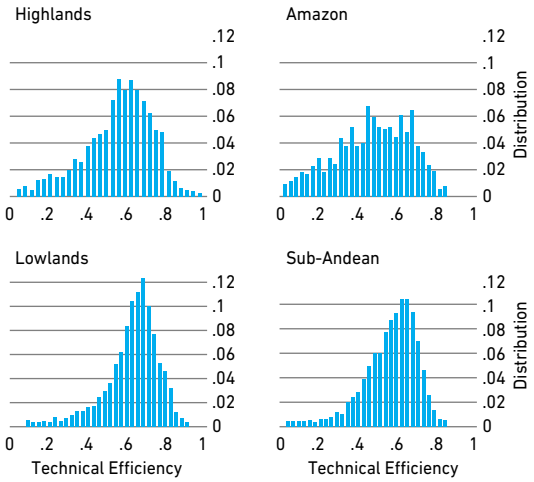
23 The only exception is capital in Highlands, which exhibits a negative sign, perhaps because of the limitations of the variable, which considers only tractor capacity (horsepower) and not the amount of energy effectively used on the farm. In addition, the capital variable does not include the use of any other type of machinery by the UPA (such information was not collected by ENA).

Figure 23. SFA and MFE by Macro-region

a) Average and distribution of technical efficiency by Macro-Region

Technical Efficiency (TE)					
Macro-Region	Number of observations	Average	Stand. Dev.	Min	Max
Highlands	1,889	0.56	0.17	0.03	0.99
Amazon	510	0.46	0.19	0.01	0.85
Lowlands	2,698	0.63	0.12	0.07	0.92
Sub-Andean	5,045	0.57	0.12	0.02	0.85

b) Histogram of technical efficiency by Macro-Region



Source: Authors' elaboration

Figure 23 below shows the results of the technical efficiency estimates for each macro-region. While these efficiency measures are not comparable across regions, their distribution can be analyzed, as shown in the histogram displayed in Figure 23b. The technical efficiency of UPAs is more heterogeneous in the Highlands and Amazon Regions, particularly the latter (as shown by the higher standard deviation and longer tails in the distribution). In the Lowlands and Sub-Andean Regions, a tighter distribution is observed, indicating that efficiency values tend to concentrate around the mean value. The differences in the dispersion of technical efficiency within each macro-region suggest that policies to increase agricultural productivity will need to be tailored to each region.

For the SFA, technical efficiency is considered to be a function of a set of variables (described in the previous section) that are related to the characteristics of producers and UPAs, as well access to services such as credit and information. This approach makes it possible to identify the main determinants of technical efficiency in each macro-region, which are shown in Table 15. The results show that irrigation significantly reduces inefficiency in all four regions. This effect occurs in a context in which irrigation adoption is quite limited, both in the Andean areas (29 percent of Highland UPAs and 33 percent of Sub-Andean UPAs) and lower areas (7 percent of Lowland UPAs and 5 percent of Amazon UPAs). From a policy perspective, and considering the technical possibilities and irrigation potential in each macro-region, investments in irrigation infrastructure appear likely to improve the technical efficiency of farmers, particularly those with crops exposed to drought risks and crops that are seasonally grown.

Access to credit is effective in reducing inefficiency in the Lowlands and the Sub-Andean Regions, which are already the regions with the greatest access to loans. Credit programs are expected to be effective in regions with higher economic dynamics, and among producers who are more integrated into the market. In regions where traditional and mainly subsistence agriculture

Table 15. Results: Determinants of technical efficiency in Macro-Regions Second Stage (dependent variable = technical inefficiency score)

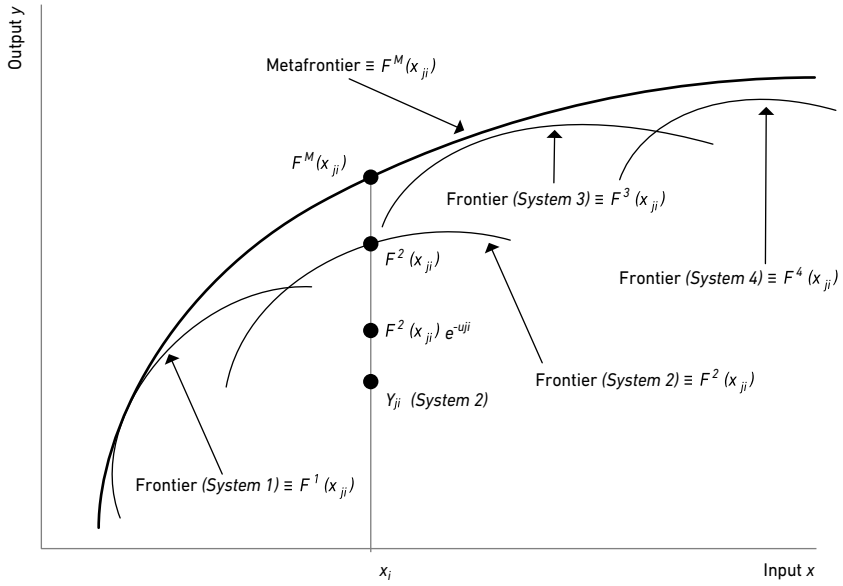
Independent variables	Highlands	Amazon	Lowlands	Sub-Andean
Female producer (1 = yes, 0 = no)	0,4841***	0,1992	0,6580***	0,1545
	(0,1388)	(0,2644)	(0,1990)	(0,1164)
Producer belongs to association (1 = yes, 0 = no)	-0,4303**	-0,0858	-0,2265	-0,3958**
	(0,2129)	(0,3404)	(0,2913)	(0,1873)
Producer obtained credit (1 = yes, 0 = no)	0,1611	-0,3249	-0,4107*	-0,6039***
	(0,2489)	(0,3289)	(0,2279)	(0,1740)
Household size (# members)	-0,0473*	-0,0066	0,0039	-0,0091
	(0,0284)	(0,0351)	(0,0340)	(0,0198)
Producer has access to telephony (1 = yes, 0 = no)	-2,5652***	-0,1903	-3,2679	-0,2984
	(0,4385)	(0,4243)	(0,0000)	(0,2757)
Harvested area (hectares)	-0,1545***	0,0168	-0,0158	0,0138
	(0,0444)	(0,0185)	(0,0097)	(0,0085)
Receives information on climatic events in the agricultural sector (1 = yes, 0 = no)	-0,2266**	0,4708**	0,2506	-0,1385
	(0,1102)	(0,1958)	(0,1600)	(0,0872)
Producer has access to irrigation (1 = yes, 0 = no)	-0,2493**	-1,9964**	-1,3202***	-0,3063***
	(0,1232)	(0,7792)	(0,4347)	(0,1067)
Constant	1,2692***	0,2728	0,8385***	0,0913
	(0,1920)	(0,3263)	(0,2799)	(0,2010)
Observations	1889	510	2698	5045
Chi-square	2274,6	334,0	1983,1	4429,2
Log Likelihood	-2437	-737	-4170	-7345
σ_v	0,689	0,698	1,050	0,905
Prob. > chi2	0,0000	0,0000	0,0000	0,0000

Source: Author's elaboration. *** Significant at 99%, ** significant at 95%, * significant at 90%.

prevails (such as the Highlands), such policies will have limited impacts if other pressing gaps in connectivity and access to basic services are not addressed.

Collective action through participation in a producer organization reduces inefficiency, especially in Highlands and Sub-Andean Regions, where land holdings are highly fragmented. Producers who form an organization, association, or cooperative are in a better position to overcome barriers in obtaining credit, negotiate cheaper volume-based purchases, take advantage of economies of scale, share risks, and more easily gain access to technical assistance and other services. This result suggests that policies and programs that promote organization and collective action among producers, especially in the Andean areas, are more likely to improve the livelihoods of peasant families than policies and programs targeting individual farmers.

Figure 24. Meta-frontier production function for different production systems



Source: Melo-Becerra and Orozco-Gallo (2017)

Access to a telephone (either a landline or mobile phone) is also relevant for reducing inefficiency, specifically in the Highlands, where access (35 percent) is lower than in all other macro-regions. The diffusion of mobile phone services in particular widens access to information for poor producers who are far away from agricultural service centers; otherwise they would obtain information only through sporadic visits by extension workers and other technicians.

Female-headed UPAs have lower levels of efficiency. It may be that these households lack training in production techniques, encounter more severe time constraints, or lack access to remunerative markets.

4.4.2. Stochastic meta-frontier efficiency by macro-region

A stochastic MFE analysis provides information on differences in efficiency across regions by comparing technical efficiency among groups of producers who use different technologies. In the first stage of the analysis, standard SFA techniques are used to estimate the specific frontier of each group. In the second stage, the meta-frontier is estimated using the pooled estimates of the regional frontiers. Since this second-stage estimation is still based on a stochastic frontier regression, the technology gaps represented by the one-sided term can be further specified as a function of geographical/environmental variables beyond the control of firms and a vector of unknown parameters to be estimated, including a set of natural and geographic factors that explain differences in technology adoption. The meta-frontier efficiency (MFE) is the measure of the technical efficiency of each production unit relative to the meta-frontier (Figure 24).

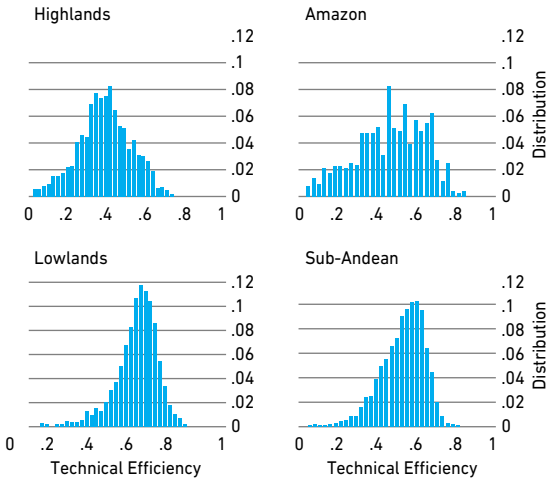
Figure 25 below shows the technology gap estimates and the final meta-efficiency measures. The region with the highest meta-technology efficiency is the

Figure 25. Meta-frontier estimations

a) Technology gap ratio and meta-efficiency by macro-region

Region	TE	TGR	MTE
Highlands	0.56	0.70	0.39
Amazon	0.46	0.94	0.44
Lowlands	0.63	0.87	0.55
Sub-Andean	0.57	0.87	0.50
Total	0.58	0.84	0.49

b) Histogram of meta-technology efficiency



Source: Authors' elaboration

Lowlands, followed by the Sub-Andean Region. The Highlands have the lowest meta-technology efficiency values. The largest technology gap ratio is observed in the Highlands. The lower technology gap ratios in the other regions indicate that they are closer to the national technological frontier. The histogram of the distribution of meta-technology efficiency by region (Figure 25b) shows that producers in the Lowlands and Sub-Andean Regions display greater homogeneity in meta-technology efficiency. This finding indicates that future efficiency gains in these regions will depend on technological improvements that move the frontier of these regions and at the same time increase productivity.

Because meta-technology efficiency within the Highlands and Amazon Regions is so heterogeneous—in other words, very efficient producers are found alongside very inefficient producers—one option to enhance productivity in these regions may be to enable the least efficient UPAs to adopt the productive practices and technologies used by the most efficient UPAs. To explore this possibility, differences in the characteristics of Highland and Amazon UPAs were analyzed by meta-technology efficiency quintile (see Table 16).

There are some differences between the more efficient and less efficient Highland UPAs. The most productive UPAs are larger, focus more on quinoa production and less on potatoes, are less likely to be female-headed, have better access to credit and mobile phones, and are more likely to belong to a producer organizations.

In the Amazon Region, there are no significant differences in farm size between UPAs with different levels of technology efficiency. However, the most efficient UPAs devote less land to bananas and plantains and have more access to permanent sources of irrigation.

These results suggest that improvements in agricultural productivity could be promoted by improving the access of less efficient producers to the practices and

Table 16. Characteristics of producers by Macro-Region and Meta-Technology Efficiency quintile

a) Highlands

ALTIPLANO/HIGHLANDS	Technology Efficiency Quintile				
Variable	1	2	3	4	5
Average Efficiency Score	0,29	0,49	0,58	0,66	0,77
Harvested area (ha)	0,96	0,97	1,11	1,49	4,98
% growing POTATOES	73 %	74 %	73 %	73 %	52 %
% growing QUINOA	21 %	20 %	21 %	32 %	51 %
% growing WHEAT	12 %	20 %	18 %	10 %	3 %
% female producers	23 %	15 %	12 %	8 %	8 %
% belonging to association	4 %	6 %	8 %	17 %	24 %
% accessed credit	3 %	3 %	4 %	10 %	11 %
% with access to mobile phone	28 %	33 %	35 %	37 %	42 %
% received climatic information	56 %	64 %	66 %	66 %	74 %
% equipped for irrigation	24 %	30 %	28 %	31 %	30 %
Household size	3,17	3,55	3,68	3,94	3,81

b) Amazon

AMAZON	Technology Efficiency Quintile				
Variable	1	2	3	4	5
Average Efficiency Score	0,18	0,37	0,48	0,59	0,71
Harvested area (ha)	3,05	2,34	1,92	2,46	2,53
% growing CASSAVA	24 %	37 %	35 %	27 %	39 %
% growing BANANA/PLANTAIN	47 %	49 %	33 %	39 %	20 %
% growing CORN	29 %	50 %	36 %	48 %	31 %
% growing RICE	18 %	28 %	33 %	34 %	27 %
% female producers	13 %	9 %	6 %	10 %	16 %
% belonging to association	6 %	7 %	6 %	7 %	10 %
% accessed credit	6 %	5 %	11 %	10 %	9 %
% with access to mobile phone	35 %	31 %	34 %	34 %	34 %
% received climatic information	87 %	75 %	70 %	58 %	72 %
% equipped for irrigation	0 %	0 %	1 %	3 %	21 %
Household size	4,45	4,49	4,36	5,09	4,17

Source: Authors' elaboration

technologies used by more efficient producers. For example, irrigation in specific areas of the Amazon Region could contribute significantly to improvements in the agricultural productivity of less efficient UPAs. In the Highlands Region, the initial SFA suggests that a set of complementary measures is required to enhance efficiency, such as the promotion of producer organizations and improvements in access to land, connectivity, and agricultural information.

4.4.3. Stochastic meta-frontier efficiency by macro-region and major crops

Although the previous analysis provides a general picture of differences in average technical efficiency between macro-regions, it is very likely that these differences are related to different technologies and characteristics of the mix of crops grown in each macro-region. A more detailed analysis that explores differences in efficiency levels across producers of the same crop who are located in different macro-regions could clarify the reasons for the productivity differentials and potentially reinforce the results of the previous analysis. For instance, it would help to determine whether the observed differences in productivity of a given crop across regions are the result of differences in producers' ability to make optimal use of productive resources or the result of differences in technology or context.

This type of detailed analysis at the crop level is possible only for crops that are grown in more than one macro-region and for which there are a reasonably large number of observations in the ENA 2015 data. Crops that meet these conditions are potatoes and wheat (produced in the Highlands and Sub-Andean Regions) and rice (produced in the Lowlands, Amazon, and Sub-Andean Regions). Important crops that are not considered in the analysis, since they are mostly produced in one macro-region, include soybeans (Lowlands) and quinoa (Highlands).

The crop-level analysis mirrors the results of the macro-region analysis. Figure 26 suggests that producers of potatoes and wheat in the Sub-Andean Region are more productive than producers of those crops in the Highlands. The greater meta-technology efficiency of the Sub-Andean Region would be explained by the lower technology gap ratio (better production processes and/or external conditions) rather than by better use of productive resources (at least in the case of wheat). To improve productivity, potato and wheat producers in the Highlands Region will need either to adopt improved technology or switch to higher-value crops.

In the case of rice, there are no significant technological differences between the Amazon, Lowlands, and Sub-Andean Regions, although the technical efficiency of Lowland and Sub-Andean producers is higher than the efficiency of producers in the Amazon Region. In the Amazon Region, the distribution of meta-technical efficiency is flatter, and the peak of the distribution is located farther away from the frontier, indicating that efficiency among Amazon rice farmers is more variable and that relatively large number of farmers are operating at some distance from the frontier. Policy measures to increase their efficiency would need to focus on improving their crop management capacity—for instance, by promoting access to irrigation, as suggested by the initial SFA.

4.5. Analyzing differences in technical efficiency and meta-technical efficiency by farm size and major crop

4.5.1. Farm size and efficiency

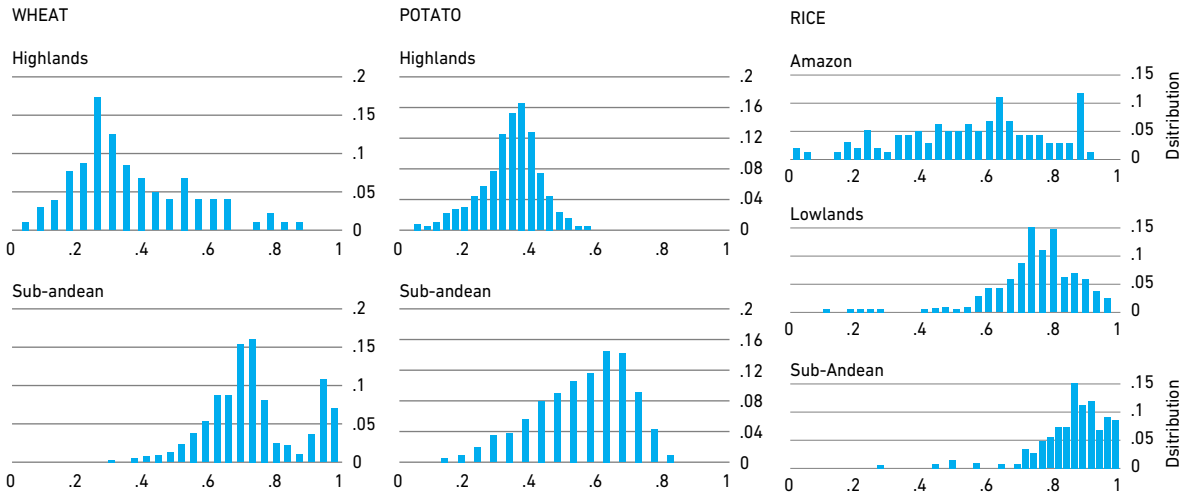
After exploring the differences in technical efficiency across macro-regions, the analytical focus now turns to the relationship between farm size and meta-technical efficiency. The analysis takes advantage of the previously estimated technical efficiency measures

Figure 26. Technical efficiency: by Crop across Macro-Regions

a) Stochastic frontier and meta-frontier by crop and farm size

	WHEAT			POTATO			RICE		
Region	TE	TGR	MTE	TE	TGR	MTE	TE	TGR	MTE
Highlands	0.91	0.39	0.36	0.59	0.57	0.34			
Amazon							0.53	0.99	0.53
Lowlands							0.76	0.97	0.74
Sub-Andean	0.74	1.00	0.74	0.55	1.00	0.55	0.89	0.97	0.85
Total	0.77	0.90	0.68	0.57	0.82	0.46	0.74	0.97	0.72

b) Histograms of meta-technology efficiency of crops and Macro-Regions

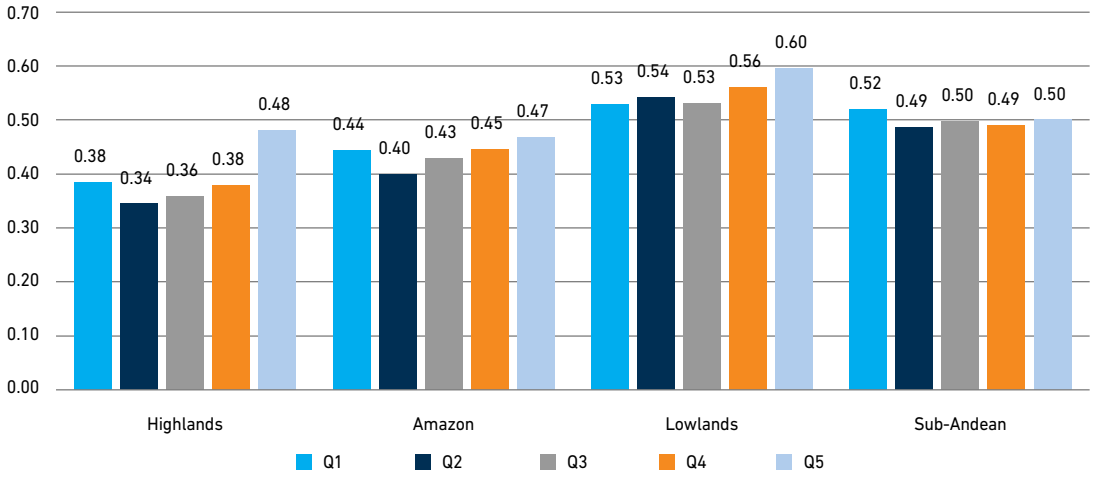


Source: Authors' elaboration

for the macro-regions to explore the relationship between UPA size and technical efficiency. It calculates average efficiency levels of UPAs (grouped by quintile of cultivated area to represent farm size) in each macro-region (see Figure 27 below). This analysis shows higher efficiency among larger UPAs in the Lowlands and Highlands Regions, and to some extent in the Amazon Region. It is worth mentioning, however, that smaller UPAs in the latter two regions also present relatively higher technical efficiency than medium-sized UPAs. Finally, in the Sub-Andean Region technical efficiency does not vary significantly across the farm-size quintiles.

While these results suggest that the relationship between farm size and meta-technical efficiency varies across macro-regions, they should not be interpreted to mean that this relationship always holds for all producers within each region. In fact, it is highly likely that the relationship between farm size and efficiency is strongly influenced by the type of crop being grown, and the next analysis focuses on this issue.

Figure 27. Average meta-technical efficiency by land quintile by macro-region



Source: Authors' elaboration

4.5.2. Efficiency in relation to farm size and crop

The efficiency analysis at the crop level was carried out separately for producers of four crops—soybeans, rice, quinoa, and potatoes. Those crops were selected because they were grown by the highest number of producers or had the largest harvested area. For this three-stage analysis, the producers of each crop were first classified into three UPA size ranges (small, medium, and large, relative to the universe of producers of the crop).[24] Second, different stochastic production frontiers were estimated for each of the size strata of the same crop. Third, a stochastic meta-frontier was estimated for each crop, including the three groups of producers classified by UPA size. This procedure makes it possible to analyze the relationship between UPA size and meta-technology efficiency (comparable measure) for the selected crops.

Soybeans

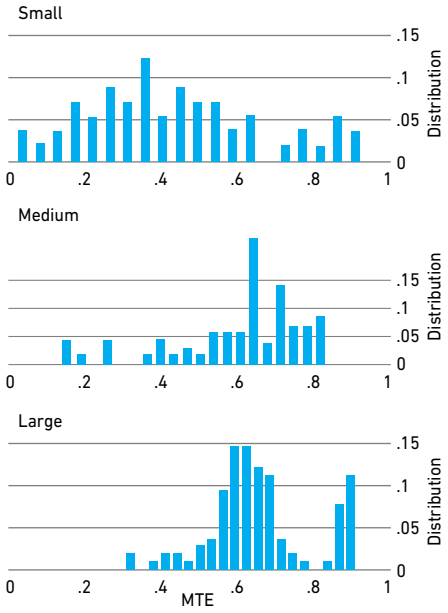
Figure 28 below shows a positive relationship between UPA size and the meta-technology efficiency of soybean producers, who are mainly located in the Lowlands Region. Larger UPAs (40–100 hectares) display greater meta-efficiency in the use of productive resources compared to smaller UPAs. This finding is consistent with the extensive nature of soybean production, which allows for economies of scale. In contrast, UPAs of less than 20 hectares are not only the most inefficient but also display highly heterogeneous meta-efficiency levels.

These results are in line with the positive relationship previously observed between farm size and efficiency in the Lowlands Region (see Figure 18, Chapter 3). They also suggest ample scope to foster productivity through policies targeting small-scale producers in the Lowlands, because increasing their productivity

24 The cut-off points for each farm-size class vary by crop due to the marked differences observed in extensive land use. The goal was to obtain farm-size groups that were relatively balanced in terms of the number of observations (producers) to ensure that robust stochastic frontier estimates for each group.

Figure 28. SOYBEAN: Technical efficiency

a) Soybean: Histogram of meta-technology efficiency



b) Soybean: results stochastic frontier and meta-frontier by crop and farm size

UPA Size	TE	TGR	MTE
0 to 20 ha	0.49	0.89	0.43
20 to 40 ha	0.69	0.88	0.61
40 to 100 ha	0.75	0.89	0.66
Total	0.67	0.89	0.59

Source: Author's elaboration

would bring higher gains in overall technical efficiency to the region. Figure 28 shows that the great majority of small-scale soybean producers (with UPAs of less than 20 hectares) operates far from the meta-frontier. A strategy that increases the access of low-efficiency producers to technology used by highly efficient soybean producers, such as irrigation and credit, could be a good alternative (as suggested by the initial SFA).

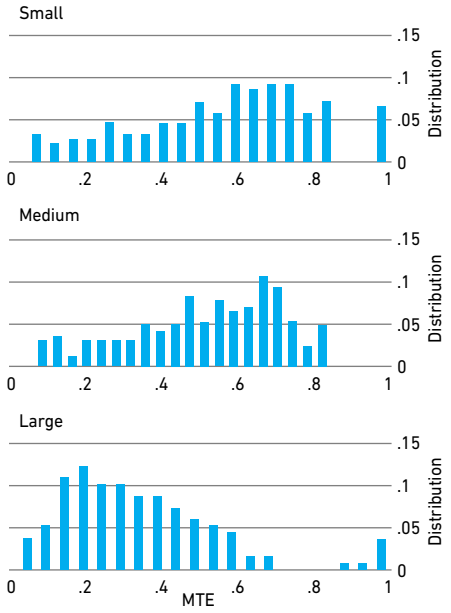
Quinoa

For quinoa, which is almost exclusively grown in the Highlands Region, the analysis shows no significant technological differences between the three farm-size groups. However, small farms (0–1 hectare) and medium farms (1–2 hectares) show a higher average level of efficiency than large farms (2–10 hectares), although levels of efficiency within all three groups are highly dispersed.

The high dispersion of MTE across all farm-size classes can be interpreted to mean that there is an opportunity to reduce these efficiency gaps through policies that bring less-efficient quinoa producers closer to the meta-frontier without the need for drastic technological changes. Examples of such initiatives include improving access to irrigation and communication networks (telephones and information) and initiatives to organize producer associations. These types of policy instruments were also suggested in light of the results of the macro-regional SFA for the Highlands Region.

Figure 29. QUINOA: Technical efficiency

a) Quinoa: Histogram of meta-technology efficiency



b) Quinoa: results stochastic frontier and meta-frontier by crop and farm size

UPA Size	TE	TGR	MTE
0 to 1 ha	0.57	0.99	0.56
1 to 3 ha	0.51	0.99	0.50
3 to 10 ha	0.33	0.99	0.33
Total	0.62	0.97	0.60

Source: Author's elaboration

Potatoes

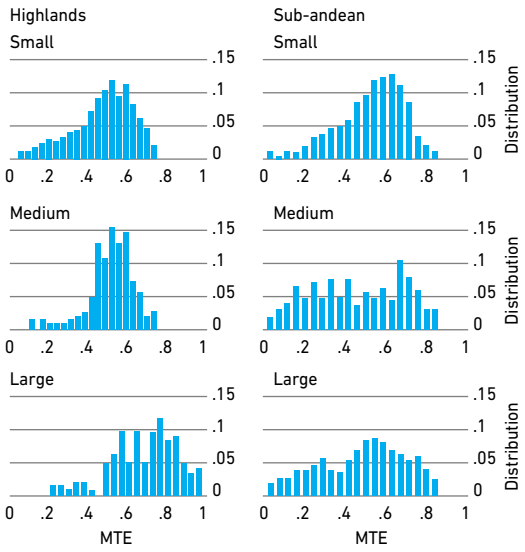
Given the large number of potato producers surveyed for the ENA 2015 (2,752 producers),[25] the analysis was conducted separately for the Highlands and Sub-Andean Regions. The results, presented in Figure 30, reveal important contrasts among macro-regions in the relationship between farm size and meta-technical efficiency. On the one hand, a positive relationship is seen between farm size and meta-efficiency in the Highlands Region, where the largest producers (2–10 hectares) were the most efficient and the smaller UPAs (with less than 1 hectare) were the least efficient. On the other hand, differences in the average efficiency of producer groups with different farm sizes were smaller in the Sub-Andean Region. Producers with the smallest holdings were the most efficient, while the meta-efficiency of producers with medium and large farms was slightly lower.

These results should be interpreted alongside the results described in Section 4.4.3, which show that meta-technical efficiency is higher among Sub-Andean potato producers due to a lower technology gap ratio (better production processes and/or external conditions) and lower among Highland potato producers. These findings suggest the need for differentiated strategies to achieve productivity growth, particularly among smallholders from the Highlands and Sub-Andean Regions. For instance, policy tools to expand the technical production frontier of the Highlands Region should be considered, such as programs that promote the adoption of better agricultural technologies and machinery, as well as policies

25 1,228 producers in the Highlands and 1,524 producers in the Sub-Andean region.

Figure 30. POTATO: Technical efficiency

a) Potato: Histogram of meta-technology efficiency



b) Potato: results stochastic frontier and meta-frontier by crop and farm size

	Highlands		
UPA Size	TE	TGR	MTE
0 to 1 ha	0.54	0.86	0.46
1 to 3 ha	0.94	0.55	0.51
3 to 10 ha	0.76	0.87	0.66
Total	0.62	0.81	0.49

	Sub-andean		
UPA Size	TE	TGR	MTE
0 to 1 ha	0.54	0.98	0.53
1 to 3 ha	0.47	0.99	0.46
3 to 10 ha	0.48	0.99	0.48
Total	0.51	0.98	0.50

Source: Authors' elaboration

that strengthen the agricultural innovation system. Although these policies would also have value in the sub-Andean Region, the high dispersion in efficiency levels among small-scale potato producers presents an opportunity to raise productivity without improvements in current farm technology. In this context, policies that push smallholders closer to the frontier can make a difference, such as initiatives that encourage producers to organize while fostering better access to credit through innovative policy tools. Access to irrigation was also identified as an important driver of technical efficiency in the Sub-Andean Region in the SFA by macro-region.

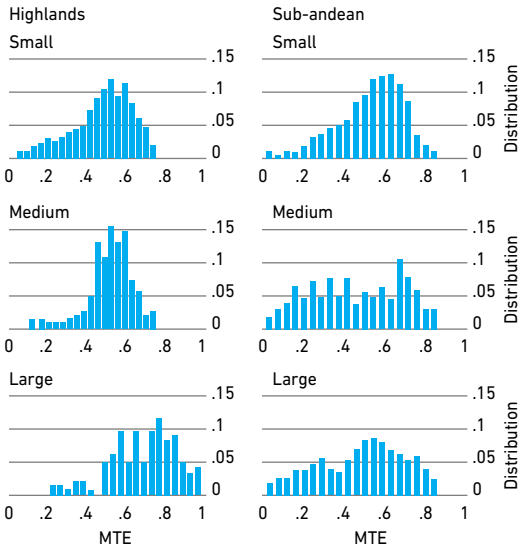
Rice

The analysis found no significant differences in the meta-efficiency of rice producers in different farm-size groups (Figure 31) and no differences in the technology gap ratio. In other words, the scale of production does not appear to be a determinant of efficiency levels in rice production. At the same time, significant heterogeneity is observed in farm efficiency levels in all groups of producers, regardless of macro-region or farm size. For example, producers in the upper quartile for technical efficiency on average have an efficiency level that is twice as high as the efficiency level of the average producer in the lower quartile. Interventions that would enable the most inefficient farmers to approach the efficiency levels of the most efficient farmers would effectively double their efficiency and result in large productivity gains to the rice sector.

Bringing less-efficient rice producers closer to the production frontier will require policies designed specifically for the context and needs of each region. As discussed, initiatives that encourage producers to

Figure 31. RICE: Technical efficiency

a) Rice: Histogram of meta-technology efficiency



b) Rice: results stochastic frontier and meta-frontier by crop and farm size

	Highlands		
UPA Size	TE	TGR	MTE
0 to 1 ha	0.54	0.86	0.46
1 to 3 ha	0.94	0.55	0.51
3 to 10 ha	0.76	0.87	0.66
Total	0.62	0.81	0.49

	Sub-andean		
UPA Size	TE	TGR	MTE
0 to 1 ha	0.54	0.98	0.53
1 to 3 ha	0.47	0.99	0.46
3 to 10 ha	0.48	0.99	0.48
Total	0.51	0.98	0.50

Source: Authors' elaboration

organize would be effective for improving efficiency in the Sub-Andean Region, where land holdings are highly fragmented. Improving access to capital in the Lowlands and Sub-Andean Regions would contribute to productivity growth in those contexts. Access to irrigation appears to be a good alternative for all three macro-regions to improve growth in agricultural productivity, based on the SFA at the macro-regional level discussed earlier.

4.6. Conclusions and recommendations

By exploring the main determinants of technical efficiency in Bolivia's four macro-regions, and by highlighting important differences in efficiency between regions, crops, and groups of producers, the analytical work described in this chapter has helped to identify opportunities and inform the design of policies to reduce the productivity and efficiency gaps in each specific context.

The econometric analysis reveals important gaps in efficiency and meta-technology efficiency, both between and within macro-regions. For example, producers in the Highlands and Amazon Regions display lower average levels of meta-technical efficiency and high heterogeneity in efficiency levels. In contrast, higher levels of meta-efficiency and a tighter distribution are observed in the Lowlands and Sub-Andean Regions, indicating that efficiency values tend to concentrate around the mean value.

These results suggest several policy measures, differentiated by macro-region, to enhance the efficiency and productivity of Bolivian agriculture. In the Lowlands and Sub-Andean Regions, for example, a focus on technological improvements could move the

production frontier toward higher levels of efficiency and productivity, and in certain instances (small-scale soybean producers) productivity gains can be achieved through interventions focused on enabling less-efficient farmers to approach the efficiency level of the most productive ones. In contrast, because of the high level of heterogeneity in meta-technology efficiency in the Highlands and Amazon Regions, a practical option for increasing productivity would be to ensure that the production practices and technologies used by the most efficient UPAs are transferred to the less-efficient ones (such as the medium-scale quinoa producers in the Highlands).

The analysis indicates that investments that could effectively increase technical efficiency and bring less-efficient farmers close to the regional frontier include support for collective action, credit programs, mobile phones, and irrigation. The efficacy of each type of investment will vary by macro-region. For example, collective action will be important for reducing technical inefficiency in areas where land holdings are highly fragmented (the Highlands and Sub-Andean Region). Programs and projects that foster collective action are more likely to improve the income of peasant families than programs that target individuals. On the other hand, improving access to credit is more likely to be an effective investment in regions with better market integration and more financial institutions (the Lowlands and Sub-Andean Regions). In the Highlands Region, where access to mobile phones and landlines is still limited,[26] better diffusion of mobile phone technology would enable information on agricultural technology and markets to reach large numbers of producers who otherwise have very sporadic and limited access to this kind of information. Finally, across all four macro-regions, investments to improve access to irrigation seem likely to be effective in reducing technical inefficiency. Irrigation would enable producers to control and intensify their use of water to improve productivity and reduce the uncertainty linked to climate cycles.

Although the analysis of technical efficiency across the macro-regions provides a general idea of measures that could improve productivity in each region, a more targeted MFE analysis focusing on particular crops and farm-size groups helps to refine those alternatives for different regions and groups of producers. For example, the analysis shows that the technical efficiency of soybean production is higher on larger farms compared to smaller ones in the Lowlands Region, probably as a result of economies of scale. The high dispersion in the distribution of efficiency among small-scale soybean producers suggests that policies that encourage the transfer of knowledge and technology from high-efficiency to low-efficiency producers in this group can make a strong contribution to productivity growth in the sector. The MFE confirms the previous finding that improved access to credit and irrigation adoption would be effective instruments to support growth in productivity in the Lowland context.

For potatoes, which are mainly grown in the Highlands and Sub-Andean Regions, the MFE points to lower technical efficiency among potato producers from the Highlands compared to producers in the Sub-Andean Region, who had a lower technology gap ratio. When results were disaggregated by farm size in each region, small-scale potato producers were found to be less efficient in the Highlands Region but not in the Sub-Andean Region. From a policy standpoint, these findings suggest the need for different strategies to achieve productivity growth in these regions, particularly among smallholders.

26 According to the 2013 agricultural census, 34 percent of the rural households reported having fixed or mobile telephony in 2012. this percentage reached 82 percent in the urban areas. While the situation would have improved by 2015 (the year of the ENA), the access of more and more farmers to mobile phones provides enormous opportunities to reach them with knowledge and a range of services.

For instance, the efficiency of medium- and small-scale potato farmers in the Highlands could be improved through measures to expand their technical production frontier, such as programs that promote the adoption of better agricultural technologies (peer to peer exchanges, access to new inputs and machinery), as well as programs to strengthen the agricultural innovation system. On the other hand, in the Sub-Andean Region, the high dispersion in efficiency levels of small-scale potato producers can be seen as an opportunity to raise productivity without the need to improve current farm technology; in this case, policies should focus on bringing less-efficient producers closer to the technical production frontier through programs that increase collective action and access to irrigation and credit.

It is worth mentioning that the MFE found no significant differences in the efficiency of rice producers in different farm-size groups, and no differences in the technology gap ratio. The substantial heterogeneity in farm efficiency levels observed among all groups of rice producers, however, means that important productivity improvements could be achieved by bringing the less-efficient rice producers closer to the production frontier. The specific policy measures will depend on the context and needs of each region. Initiatives to encourage producers to organize are likely to be effective in improving efficiency in the Sub-Andean Region, given the highly fragmented land holdings. Improving access to capital in the Lowlands and Sub-Andean Regions would enable less-efficient producer to move closer to the production frontier. And again, improving access to irrigation would be a good alternative for improving efficiency in all three macro-regions where rice is produced.

Finally, it is important to acknowledge the limited scope of this exercise in terms of the set of variables that could be considered. The quality and scope of data collected must improve to allow for more robust estimations of productivity at disaggregated levels, including STF/MFE estimates, but also estimation of TFP.

5.

Competitiveness of Bolivia's agriculture

Photo: Programa de Alianzas Rurales (PAR), EMPODERAR

In Bolivia only a small number of agricultural commodities are integrated with global value chains, and even those commodities encounter constraints that hinder their competitiveness. Strong demand and supply forces have fueled the dramatic increase in agricultural growth observed in the Santa Cruz region, but these forces have been largely absent in other regions, where agriculture remains much less competitive. To understand the factors that determine or disrupt competitiveness, this chapter explores the competitiveness of agriculture in Bolivia in relation to global benchmarks and comparator countries. It provides a general perspective on how to unlock the competitiveness of Bolivian agri-food systems and as well as specific assessments of the main constraints and opportunities in key value chains for agriculture and agribusiness, including constraints related to geographical heterogeneity.

5.1. Competitiveness performance: Evidence provided by global benchmarks

5.1.1. Common enablers

The Global Competitiveness Index (GCI) 2018 is calculated based on 12 indicators that are considered to influence competitiveness. Bolivia ranks in the bottom third of the 140 countries compared in the GCI, holding the 105th position. Bolivia does not approach the GCI median score of 70 for any of the dozen "competitiveness pillars" of the index. The country earns its best marks for macro-economic stability (84) and financial system (85), and the worst for business dynamics (130), institutions (129), and labor market (126). In the group of LAC counties, Bolivia ranks near the bottom, outperforming only Venezuela and Haiti. Compared to the best performer in the LAC Region, Bolivia must narrow important gaps, even in areas where it ranks best (Table 17). Compared to its structural peers, Bolivia's performance in relation to critical competitiveness pillars is also disappointing. For business dynamism, labor markets, market size, and institutions Bolivia has notably divergent scores from the highest performer among its structural peers.

Another important global indicator that highlights the influence of regulatory frameworks and administrative procedures on business operations and private investments is the Doing Business Indictor (DBI). For this indicator, Bolivia places in the bottom tercile, ranking 156th of 190 countries, performing below regional and structural peers (except Cameroon) and other countries in Central America, such as Guatemala, Honduras, and Nicaragua. The 2018 IDB report acknowledges Bolivia progress on trading across borders by implementing the Sistema Único de Modernización Aduanera (SUMA), an automated customs data management system.

To understand the influence of regulatory frameworks and administrative procedures on business operations and private investments in the agricultural sector in particular, the World Bank developed the Enabling the Business of Agriculture (EBA) indicators. Insights into Bolivia's performance from the 2017 EBA include:

- **Machinery:** Bolivia ranks 52nd of 62 countries for regulations dealing with machinery. The process for registering a tractor is virtually nonexistent.
- **Fertilizer:** Bolivia ranks 45th, considerably below the other countries. In Bolivia, Ethiopia, and Kenya, only the public sector is permitted by law to register new fertilizer products.
- **Seed:** Bolivia ranks relatively well (25th) for seed regulation, partly owing to its law requiring the labelling of seed containers and penalizing fraudulent sales of mislabeled seed. Bolivia also has strong seed registration regulations and an efficient registration process, which is seldom seen in other countries.

Table 17. Global Competitiveness Index 2018, selected results for Bolivia

Enabling Environment	Difference from highest ranked (a) LAC	Human Capital	Difference from highest ranked (a) LAC	Markets	Difference from highest ranked (a) LAC	Innovation and sophistication (a) LAC	Difference from highest ranked (a) LAC
Institutions	-22.4	Skills	-13	Product Market	-19.7	Business Dynamism	-19.3
Infrastructure	-19			Labor Market	-15.7	Innovation Capability	-14.4
Macroeconomic Stability	-26.9			Financial Systems	-25.5		
Health	-18.4			Market Size	-16.5		
	b) Structural Peer		b) Structural Peer		b) Structural Peer		b) Structural Peer
Institutions (Ghana)	-14.5	Skills (Kazakhstan)	-10.4	Product Market (Kazakhstan)	-8.8	Business Dynamism (Kazakhstan)	-21
Infrastructures (Kazakhstan)	-11.1			Labor Market (Kazakhstan)	-18.3	Innovation Capability (Ghana)	-5.8
Macroeconomic Stability (Kazakhstan)	-7.2			Financial Systems (Bolivia)	2.6		
Health (Bolivia)	4.2			Market Size (Kazakhstan)	-16.8		

Source: Global Competitiveness Index 2018

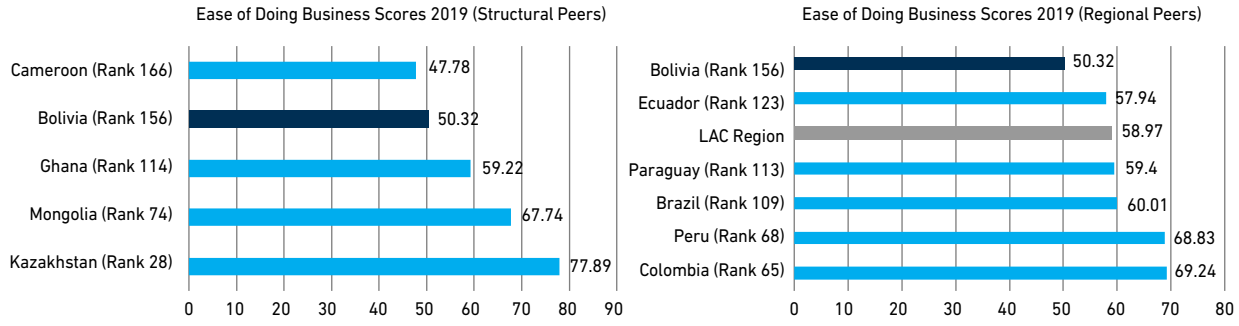
- **Finance:** Bolivia is doing remarkably well, ranking 13th. The government has made a great effort to implement regulations to facilitate financing for small-scale farmers over the past few years. Bolivia is also one of only a few countries in which financial cooperatives disclose the full cost of credit to loan applicants, participate in a deposit insurance system, and are allowed to merge to create a new financial cooperative.
- **Nondiscrimination law.** Bolivia ranks among the top-most countries for good practices in agriculture related to nondiscrimination laws and regulations.

5.1.2. Broad logistical constraints to improved competitiveness

Logistics is fundamental to value chain coordination and the efficient movement of agricultural products to market and inputs to producers. The Logistics Performance Index (LPI) is measures a country's performance in relation to several components of trade logistics (Table 18). Bolivia scores below all but two of its structural peers (it is better than Cameroon in timeliness, and better than Mongolia with regard to customs, infrastructure, international shipments, and tracking and tracing).[27]

27 Since 2007, the LPI has provided the means for benchmarking the competitiveness of logistics for 160 countries across the spectrum of country size and income level.

Figure 32. Ease of Doing Business 2016-17, selected results



Source: EBA indicators 2018, World Bank

Table 18. Logistics Performance Index 2018, selected results

	Customs	Infrastructure	International Shipments	Logistics Competence	Tracking and Tracing	Timeliness
Bolivia	2.32	2.15	2.54	2.21	2.13	2.74
Kazakhstan	2.66	2.55	2.73	2.58	2.78	3.53
Ghana	2.45	2.44	2.53	2.51	2.57	2.87
Mongolia	2.22	2.10	2.49	2.21	2.10	3.06
Cameroon	2.46	2.57	2.87	2.60	2.47	2.57
Lower Middle Income	2.37	2.37	2.57	2.50	2.59	2.96

Source: LPI World Bank, 2018

A study by the Economic Commission for Latin America and the Caribbean (ECLAC/CEPAL) to gauge logistical competitiveness of landlocked countries such as Bolivia highlights the effects of logistical constraints on agricultural sector performance. The study quantifies costs at each segment of the soybean export chain involving logistics: pre-shipment; transfer to port; port, airport, or border entry-point; transport to destination; and total inventory charges and financing costs. It finds that cost overruns can be as high as 21 percent when shipping via river ports and over 23 percent for land shipments. For export commodities such as soybeans, these cost overruns weigh disproportionately on competitiveness. The CEPAL study also confirms that the total distance of a shipment is not necessarily the best predictor of costs. The substantial transaction costs incurred in transfers, handling, demurrage, and delays significantly hamper competitiveness.[28]

Inefficiencies in logistics also affect the competitiveness of non-traditional exports. For the quinoa supply chain, a World Bank study (2014) finds that the length of time required to perform certain logistics

28 CEPAL, 2014. Logistics inefficiencies in Latin American landlocked countries. Issue No. 335 - Number 7 / 2014.

tasks varies considerably from 741 to 1,023 hours. This uncertainty is costly for producers and exporters and makes it more difficult to plan an efficient supply chain. Delays also translate into significantly increased costs, such as when a truck misses the departure of a vessel and is required to wait up to a week for the next departure. In the quinoa supply chain, land transport has an especially pernicious effect on logistics; moving quinoa from the production zone by truck to the Port of Arica can take from 24 to 106 hours. The variation in transport time is mainly the result of delays at the Tambo Quemado and Chungara border crossings, caused by limited hours of operation, congestion, and system failures, among other reasons.

One key area where logistical efficiency can improve is inspection and certification, overseen by SENASAG (Servicio Nacional de Sanidad Agropecuaria e Inocuidad Alimentaria), the national agency responsible for the health and safety of food and agricultural products. A 2014 World Bank analysis of transportation and logistics in Bolivia[29] concludes that routine delays associated with SENASAG inspection and certification create long turnaround times that are incompatible with business and trade realities. Interviews with respondents in various value chains reinforce this conclusion. They note that SENASAG is efficient at border crossings (which is corroborated by Bolivia's relatively high DBI score for ease of trading across borders) but that customs warehouse delays can last up to two weeks and that it can take as long as 43 days to issue sanitary certificates.

The government has made tremendous efforts to improve road infrastructure, from 1990 to date, the nationwide road network has increased by about 70 percent, over the last 10 years (2008-2018), the public investment in the primary road network grew by 82 percent. As a result, progress in creating the conditions for better logistics is encouraging, but an integrated vision and strategy for logistics could potentially achieve more. The increase in paved roads in Bolivia has promoted connectivity and reduced travel times for passengers and freight. Airports are being improved, and growing volumes of cargo are being traded. Even so, an integrated logistics vision and strategy could be an effective way to attract investments in infrastructure and improved logistic services, promote regulatory reforms, and identify opportunities for institutional strengthening.

5.2. Development of competitive agricultural value chains: Approaches and examples of key value chains

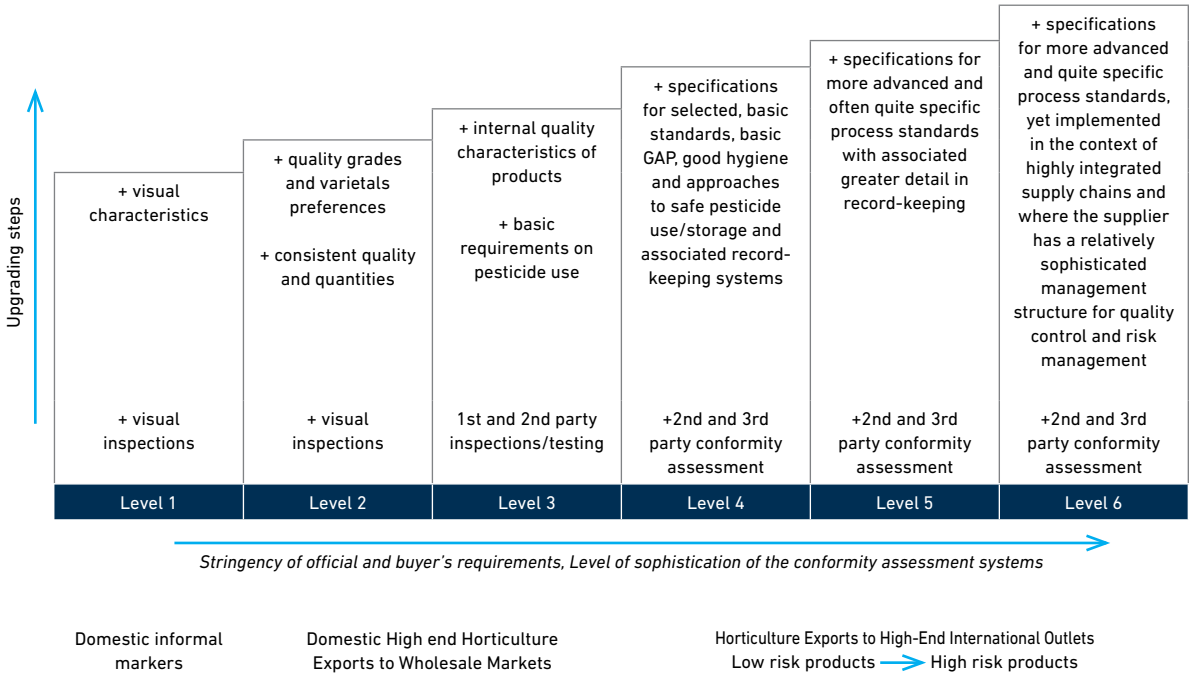
5.2.1. Approaches to develop competitive value chains

Bolivia's approach to developing competitive value chains has largely focused on reducing the dependence on imports, partly because of the food crisis more than a decade ago. The limitations of focusing merely on internal markets are now clearly recognized in the government plan (PDES), opening opportunities to work with export value chains to enhance economic diversification and rural livelihoods.

A framework developed by the World Bank (2011) is useful for understanding the strategies that Bolivia has followed to develop value chains. Figure 33 displays, in stylized form, the requirements associated with a series of markets, ranked in increasing order of sophistication from Level 1 (value products sold into informal domestic bulk markets) to Level 6 (highly perishable, high-value products sold into sophisticated international markets). At one end of the spectrum, Levels 5 and 6 represent highly demanding markets, implying the need for strong value chain coordination and large investments in infrastructure, logistics, and coordination mechanisms. At the other end of the spectrum are the domestic markets, with

29 "Transport & Logistics: Bolivia's Path towards Competitiveness", June 2014 (background paper, unpublished).

Figure 33. Requirements associated with increasingly sophisticated agri-food markets



Source: World Bank 2011

much less stringent demands in terms of quality and conformity assessment procedures.

For the most part, the development of agricultural value chains in Bolivia has targeted Levels 1–3, markets that satisfy domestic demand or that have very little quality differentiation, but in which improvements have the potential to benefit large number of farmers. The potato chain (described in detail later in this chapter) is one example. It is important to note that most efforts to increase growth in these value chains have emphasized gains in production much less on productivity, value addition, and product differentiation based on quality or some other trait.

Perhaps the most important efforts to differentiate products for export, targeting Level 3–4 markets, are linked to organic quinoa (*quinoa real*) in the Highlands Region, organic coffee in the Amazon Region (Yungas Region), and chia and Brazil nuts (also in the Amazon Region). In most cases, these efforts have suffered considerable setbacks from changing supply and market dynamics (quinoa) and/or from the lack of coordinated public-private sector value chain strategies, with a clear shared vision and objectives. Such strategies, as in the case of coffee, would have given continuity to successful early initiatives for export product differentiation supported through international cooperation.

The strategy to improve the export competitiveness of commodities (oilseeds in particular) is largely based on access to inexpensive land and preferential trade agreements with Andean Community markets. Those advantages are currently eroding, calling on Bolivia to alter its approach to enhance competitiveness by focusing on a cost-reduction strategy based on the adoption of improved technology, productivity

improvements, improved logistics, and a policy environment that supports these goals. This cost-reduction strategy should go hand-in-hand with the implementation and communication of commitments to sustainability.

Perhaps the most telling example of successful value chain development in Bolivia comes from the nascent grape and wine value chain in the Sub-Andean Region, which chose to differentiate its wines by emphasizing that they are produced at higher altitudes (*vinos de altura*). International cooperation played a critical role in enhancing the visibility of Bolivian wines in domestic and international markets. Government programs have supported productivity improvements and promotion strategies. Now that international support for the industry is coming to an end, the private sector must assume a strong leadership role, working closely with the public sector to build on this early success and address critical competitiveness issues, such as the introduction of grape varieties specifically for export markets, export promotion strategies, and quality certification.

Some of the efforts by non-governmental organizations to support the grape and wine value chain involved working with local governments to identify economic opportunities that could build on grape and wine production and processing, such as tourism (*la Ruta del Vino*) and cheese production. These territorial and cross-sectoral approaches show considerable potential to increase economic activity in rural Bolivia.

5.2.2. Competitiveness constraints and opportunities for key agricultural value chains

Aside from the sector-wide competitiveness constraints identified in the previous section, Bolivia's key agricultural value chains face more specific competitiveness constraints and opportunities. They are discussed in the spotlight sections that follow, along with potential strategies to improve competitiveness. The value chains include potatoes (productivity and market integration to benefit large numbers of Bolivian producers—Levels 1 and 2), beef (building a sustainable sector to supply domestic and export demands—Levels 3 and 4), coffee (growing as a specialty industry—Level 4), quinoa (enhancing positioning in differentiated markets—Level 4), and soybeans (shifting the technological frontier and reducing the environmental footprint—Level 3).

POTATOES: Productivity and market integration to benefit large numbers of Bolivian producers

While not a full-fledged value chain in many respects, potato production and marketing may be considered a traditional chain with a small but promising frontier for new chain opportunities. The potato holds a privileged place in the Bolivian diet, rural production, history, and culture. While not altering its traditional role, this traditional chain needs substantial impetus to increase its productivity and essential competitiveness.

Production and producer profile. Bolivia and neighboring Andean are the genetic home of the potato, which exhibits staggering biodiversity in Bolivia. Each locale has its distinctive set of varieties, and 1,500 varieties are thought to be grown across the country. The prime growing areas are in the Sub-Andean and Highlands Regions, but potatoes—grown in two-thirds of all municipalities (221 of 337)—flourish everywhere except for Pando and Beni Departments. Bolivia produces over 1 million metric tons (1.18 million in 2017) across 183,000 hectares, and Cochabamba is the single largest producer, with 28 percent of national production. The crop is grown mostly by small-scale farmers, although larger operations in Santa Cruz have shown that mechanized production systems achieve yields that are nearly double the national average. To preserve its wealth of potato genetic resources, Bolivia is the rare lower-middle-income country with a gene-bank, although

Table 19. Comparison of Potato Yields in LAC and Beyond, 2017 (MT/Hectare)

	US	Argentina	Chile	Brazil	Bolivia	World Ave
Average Yield	46,4	29,3	23,8	18,4	5,5	27,38

Source: FAOSTAT, 2017.

it would benefit from institutional strengthening and technical assistance.

Market profile and potential. A characteristic of the potato market worldwide is that only a small fraction of potatoes is exported (3 percent average worldwide), even by the largest producers (China and India). As a perishable crop that has a low value in relation to its weight, potatoes are costly to transport, so they tend to be grown for consumption by the farm household or sold in local markets. Bolivians are world champion potato consumers, averaging 95–100 kilograms per person annually, led by Cochabamba Department with 151 kilograms per person. Although Bolivia exports very little of its production (conforming to the pattern 3 percent), significant potential exists for diversification and adding value. A distinguishing feature of the traditional potato value chain is that wholesalers buy the crop at dispersed traditional farmers' markets (*ferias*) in the production zones and transport the potatoes to wholesale storage and market facilities in cities.

While fresh potatoes will remain the mainstay of the value chain, at the margin various markets present far more lucrative opportunities compared to the slim margins from selling fresh potatoes in a competitive marketplace. The first is *chuño,* a traditionally dried product made from a particular variety of yellow potato. *Chuño* has the remarkable ability to be stored for up to 10 years, aiding food security and reducing risk. Forty-four percent of the very small potato exports from Bolivia (100 tons in 2018) consisted of canned *chuño* exported to Spain. Other emerging opportunities include frozen potatoes for the domestic fast-food trade, which are currently imported from Argentina, Peru, and even Canada. Food manufacturers also need to develop locally sourced and produced potato chips to compete with expensive but popular imports. A highly significant import-substitution opportunity is to increase national potato production to prevent the current shortfall, estimated at 55,000 tons, from being filled by illegally imported potatoes from Peru.

Productivity. Just as the Bolivian value chain is traditional, so too are its yields, having changed little over time. As depicted in Table 19 below, even neighboring countries have yields close to the world average, which is five times greater than Bolivia's average yield, while yields of leading producers are even higher.

Logistics and chain management. Logistical inefficiencies are primarily structural, associated with the rural collection and assembly (*acopio*) of produce from large numbers of dispersed producers and highly unusual diversity of the produce. The principal public good bearing on transaction costs is the transportation network.

Strategy to improve competitiveness. Without any misguided notions of displacing the domestic consumption of a broad variety of traditional potato varieties, there is an overwhelming need to improve the competitiveness of the chain. The essence of the traditional sector will not be compromised by increas-

ing productivity without displacing local diversity with non-native high-yielding varieties. Increasing yields significantly requires public and private investment across a range of producer support activities: extension of best practices and technical assistance, plant health disease control measures, soil fertility protection and enhancement, small-scale irrigation systems and water-user organizations, improved post-harvest handling and storage techniques, and financial services. An important step for the development of potato varieties would be to further strengthen the genebank to preserve its valuable collection of potato varieties and extend the usefulness of these genetic resources, possibly in collaboration with other genebanks such as those associated with the International Potato Center in Peru and the International Center for Tropical Agriculture in Colombia.

The second leg of the strategy, which the government has been pursuing, is to focus on realizing and expanding the various market opportunities outlined already, such as the production-consumption gap to displace Peruvian contraband potatoes. Another significant opportunity to increase producer income is to link investments in irrigation and water management to reaching the large market window for local consumption when prices are highest. Until the typical harvest period from February to June, prices are at their peak. With carryover from storage, prices start to climb by October, peaking typically in February. Using small-scale irrigation, particularly pressurized systems, producers can target that window. The other opportunities mentioned in food processing (frozen potatoes, chips, and other products) rely on private initiative, but the public sector can proactively seek to promote interest, including with international partners. The experience of the development of the native potato value chain in Peru, offers important lessons in terms of institutional innovations that Bolivia could pursue.

BEEF: Building a sustainable sector to supply growing domestic and export demands

The cattle and beef industry in Bolivia, with its high degree of informality and limited industrialization and exports, does not constitute a full-fledged or highly articulated value chain. Eighty percent of transactions are informal and generate no tax revenue. Productivity is low, although good potential exists to improve it if policy and investment measures provide the means and incentives to establish a more competitive value chain.

Production and producer profile. Census data indicate that in 2013 ranchers in Santa Cruz Department grazed about 41.7 percent of the cattle produced for beef, followed by the Beni Department with 35.6 percent. In recent years the "industry" has produced over 260,000 tons of meat, of which only 5 percent has been exported. The small export channel, entirely based in Santa Cruz, consists of some 200 producers selling to three packing houses approved to export beef to Peru and other countries (very recently China).

Market profile. Approximately 30 buyers truck the cattle they purchase to market, while many ranchers deliver their cattle on the hoof, with all of the attendant issues of weight loss, stress, and delays, particularly during the rainy season. All of these intermediaries are required to hold a SENASAG authorization. The buyers often purchase on credit, lacking well-established financial services to support the cattle and beef market. The outlets for the meat are approximately 500 retailers around the country. Some wholesale function exists in El Alto near the capital, La Paz. Slaughterhouse facilities are typically cramped and inadequate. Of the US$12 million in beef exported from the three approved meat packing plants in 2017, about half targeted the market for boned meat, with some value-added destined for hamburger meat sales in Peru, Ecuador, and Co-

lombia. The other half was exported as unprocessed meat to Peru, Vietnam, and Brazil.

Productivity. Cattle production remains essentially traditional, with few incentives or resources to raise productivity. Ranchers in Beni Department depend entirely on extensive grazing; the land has a relatively low carrying capacity (1 head per hectare) and there is little pressure to use land for alternative production. The Nelore breed is well adapted, so there are few incentives to initiate major breeding programs. The situation in Santa Cruz Department with Brahman cattle is similar, although producers' use of rations reflects the higher opportunity cost of land and incentives for intensification. Artificial insemination is practiced in Bolivia, but no significant breeding programs or genetic research or sourcing are underway.

Logistics and chain management. The poor road infrastructure in Beni Department is typical of extensive areas with low economic opportunity costs or options to generate fiscal revenue. The poor condition and maintenance of main roads and the limited network of access roads precludes trucking in many cases. Cattle drives are the standard practice, with associated animal health issues and risk of delays. The fleet of trucks and vehicles used in the beef industry is generally reported to be in poor condition.

Strategy to improve competitiveness. The current low level of competitiveness reflects a domestic market without high-value segments and little integration in export markets. It is very much the result of export policies that prioritized supplies for the domestic market, severely restricting (banning) exports between 2008 and 2012 and then establishing export quotas in 2013. The cattle and beef industry is likely to operate in its current state until higher-value export markets or domestic value-added industry are developed that offer higher profitability. Few leather and processed meat operations exist in Bolivia. The very small share of production (approximately 2 percent) that goes to an export market with some value-added provides a minimal precedent, but without more critical mass, it will be difficult to incentivize the base of the value chain. Private-public collaboration on export and enterprise promotion would be a proactive step to break out of the low-productivity and low-reinvestment cycle. Eventually the formalization and greater integration of the chain will include increased collection of taxes and use of tax revenue to invest in public goods in support of the sector. While the logical candidate for increased industrialization or exporting is Santa Cruz under current circumstances, the competitive advantage of ranchers in Beni is not to be overlooked. As low-cost producers of entirely grass-fed beef, they have the potential to capture export opportunities to satisfy high-value markets demanding grass-fed meats. If these niche markets prove feasible, then certification programs and eventually traceability protocols could readily transform some of the traditional producers into suppliers of a differentiated, even premium product. Such a development would justify upgrading one or more of Beni's 15 slaughterhouses into true packing houses with SENASAG authorization, inspection, and any other certification that may be required for export products. Overall, the sectoral strategy would need to emphasize gains in productivity, higher formalization, sanitary compliance, and a gradual strategy for differentiation in niche markets. The opening of opportunities in markets such as China, would imply attention to sanitary compliance. In China relevant issues would include traceability, residue and pathogen control and nonuse of anabolic hormones.

Strategies for growth as a sustainable industry. The prospect that expanded livestock production will exacerbate climate change is a global concern. In Bolivia, cattle are associated with deforestation and rates of forest degradation, particularly in the Chaco region, where livestock are raised in native forest areas. Furthermore, livestock are associated with large greenhouse gas (GHG) emissions, which improved production practices could minimize. The

sector would benefit from strategies to support sustainable expansion, including land use planning strategies and mainstreaming of sustainable and climate-smart practices.

COFFEE: Growing as a specialty industry

Efforts initiated in the early 2000s with international assistance to produce high-quality coffee and present farmers with an alternative to coca production has slowly yielded results. Bolivian growers received a higher average price per kilogram than growers in any other coffee-producing country, and premium high-quality Bolivian coffees attained some of the world's highest market prices. The premier coffee growing area of Bolivia offers optimal agroecological conditions yet underperforms, leaving limited alternative economic activities. Low yields, weak producer organizations, poor training, degraded soils, limited input supplies, and limited infrastructure all undermine productivity of the coffee subsector. The world coffee price fell in 2019 to its lowest point in over 13 years. Farmgate coffee prices are now below the cost of production for Bolivians. The price crisis threatens to halt exports, further weakening the industry, and the end is not in sight, as the devaluation in Brazil (the driving force) cannot be resolved easily. Both industry and the government will need to invest for the longer term to position producers for an eventual recovery and resilience in the fact of future threats.

Production and producer profile. Over ninety percent (91%) of the coffee crop in Bolivia is highland coffee (*café de altura*) produced in the Yungas Region of La Paz Department, on the humid and milder eastern slope of the Andes between 1,200 and 3000 masl. Coffee beans grow more slowly at high elevations and develop distinct organoleptic characteristics that are prized by a segment of the high-value coffee market. The remaining nine percent of the coffee crop is produced outside of the Yungas in the Departments of Santa Cruz (5 percent), Cochabamba (3 percent), and Pando (1 percent). Caranavi, a single rural municipality in the Yungas, accounts for 66 percent of national production.

Café de altura is arabica, predominantly of the long-established local (*típica or criollo*) variety, recognized in international competitions as being of the highest quality. Thirty percent of graded and sorted production is classified as specialty coffee, and seventy percent is classified as conventional coffee of superior quality.

Coffee is produced by 23,000 families, and an additional 12,000 are employed elsewhere in the coffee value chain. These smallholders operate 17,491 coffee "farms" or production plots distributed over 22,824 hectares, for an average of slightly less than 1 hectare per producer family. Most smallholders (an estimated 80 percent) belong to local producer organizations. The 90 producer organizations are affiliated with four second-tier associations or federations. While the total number of coffee farmers is about one-third as large as the number of quinoa farmers in Bolivia, the coffee value chain offers more

opportunities for value addition and generates more employment. The benefits of growing coffee are highly geographically concentrated, but the jobs creation downstream are dispersed. The Yungas region offers very few sustainable economic alternatives to coffee production.

Coffee yields in Bolivia average 370–700 kilograms per hectare, whereas the demonstrated potential yield is 900–1,200 kilograms per hectare. Yield volumes cannot be considered apart from quality, however, because the quality premium can be very high. An extreme example is a producer in the Yungas growing the specialty variety called Geisha. It garnered significant recognition in a cupping competition and sells for over US$14 per kilogram.

Market profile. Producer organizations currently have little involvement with market segmentation. Some production enters domestic market channels and some is sold directly, but most of the coffee production goes to 28 exporters selling into the vast world market for arabica coffee. The volume of coffee produced fell from its previous level of 7,800–8,000 tons to around 5,400 tons in 2018, and exports, which had held steady around 5,000 tons annually over 2000–09, dropped continuously from 4,600 tons in 2010 to 1,520 tons in 2017. Even with the downward slide of coffee prices worldwide, average prices of Bolivian coffee have risen. FOB prices of US$2 per kilogram in the early 2000s surpassed US$3 per kilogram by the end of that decade, rising to values averaging over US$5 per kilogram over 2011–17. The decline in export volume swamped the price effect, and Bolivia's export revenues have fallen from their height in 2011 of US$26 million to US$10 million in 2018.

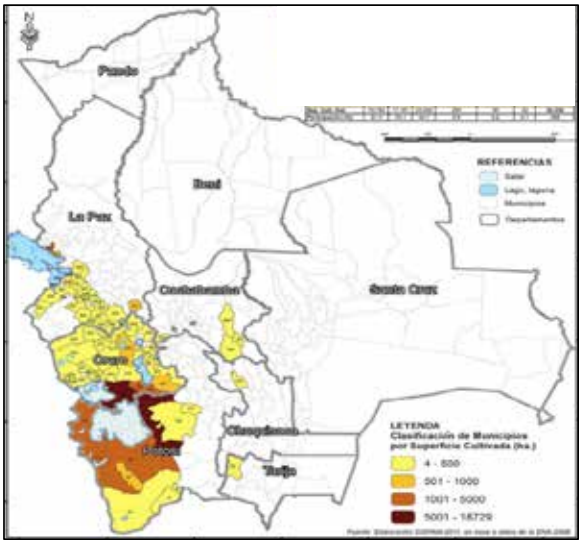
Logistics and chain management. The number of distinct links in the coffee value chain means that logistics and chain management strongly affect its overall competitiveness. Currently logistical inefficiencies result in an average of 55 days from post-harvest to the arrival of the shipping container in the exit port. Much of this delay is attributable to storage at the buyer's rural export warehouse (*planta beneficiadora*) while assembling sufficient product from various smallholders to fill a container.

Strategy to improve competitiveness. Efforts should concentrate on the prime growing area in the Yungas to ensure the highest-quality arabica coffee possible and consolidate Bolivia's growing strategic position in the coffee specialty market. Organic and fair-trade certifications would add little benefit without a strong quality-cup production industry. These efforts would also benefit the growing domestic demand for high-quality coffee in high-end hotels and restaurants, which is currently restricted due to limited supply. The investments required to position Bolivia in the specialty coffee market are multi-faceted but well recognized by the industry and government. The 2018 National Coffee Investment Program led by the Ministry of Rural Development and Lands (MDR&T) provides a clear roadmap to enhance the coffee sector's competitiveness. The six "strategic axes" of investment are to: (1) improve coffee varieties and production technology within a sustainable natural resource management approach, (2) implement a proposed new institutional and legal framework, (3) identify priority infrastructure investments, (4) support the development of agro-processing that improves coffee quality, (5) develop new and expanded market channels domestically and abroad, and (6) improve government financial credit to support private investments along the value chain. To succeed, these efforts need to be closely implemented with the private sector, including interested international buyers, particularly those linked to direct trading, and experienced development partners.

QUINOA: Enhancing Bolivia's positioning in differentiated markets

Quinoa is the Altiplano cash crop par excellence in several important respects. The crop originated in the

Highlands Region where it is grown, and the region which remains the sole producer of the organic *quinoa real* variety that is the most highly prized in the marketplace. The same nutritional characteristics that make quinoa a high-value export (it is a high-protein grain rich in minerals and micronutrients) confer a health and food security advantage to poor rural households with chronic dietary deficiencies. The low perishability of this high-value grain renders it relatively robust in the face of major transport costs and logistics hurdles that undermine Bolivia's competitiveness.



Production and producer profile. As the world market for this traditional grain only "discovered" quinoa and began developing major marketing channels in the mid–late 2000s, Bolivia dominated the nascent export market. In 2014 Peru edged out Bolivia as the larger exporter, although Peru produces the conventional non-organic variety. The two countries continue to lead production and export, with only minor exports from Ecuador or non-Andean producer countries. Bolivia's production remained near 50,000 tons from 2001 to 2009, leaping to 120,000 tons in 2012 and nearly reaching 150,000 tons in 2013. In the following year, when Peru surpassed Bolivia in total exports, world market prices peaked at around US$ 6,000 per ton. The rising volume of exports saturated the market, depressing prices since 2015.

The significant production increases attained in recent years were the result of an expansion in cultivated area and not of an increase in yield. Yields have plateaued at around 600 kilograms per hectare (a recent calculation finds that average yields over a 16-year period were 540 kilograms per hectare, with no significant upward trend). Experimental plots show that yields of 1 ton per hectare are feasible in Bolivia, but in farmers' fields, depleted soil fertility and limited control over access and timing of water are clear areas for improvement, along with mechanization; basic tillers have been shown to increase quinoa yields. An economic analysis for a representative sample of growing regions should be done to determine optimal levels of inputs and public-private investment. Other agricultural research has demonstrated promising varieties of quinoa for new areas and elevations, although they would supply conventional quinoa markets rather than markets for premium *quinoa real*.

Quinoa generates employment and income for one out of ten Bolivian agricultural producers, disproportionately to the benefit of small-scale farmers in the Altiplano. About 70,000 small-scale highland farms are estimated to produce quinoa, two-thirds of which are centered in Potosi and one-third in Oruro and La Paz Departments.[30] Given an average family size of 4–5 persons, some 300,000 of the approximately 3 million rural Bolivians benefit directly from the production and export of quinoa. Direct exports account for 44 percent of production, 23 percent goes to local markets, and 33 percent enters informal market channels in Peru. Some of the production moving

30 This figure is repletely reported in reports, since the export boom and it is uncertain how many farmers have abandoned quinoa production for commercial purposes as a result of the declining international prices.

through informal markets in Peru could possibly be retained for export from Bolivia if various measures to enhance competitiveness are adopted.

Market profile. Total revenue from quinoa exports has remained relatively low since the 2014 peak, and opportunities for a market premium will remain limited until market size expands and market segmentation develops further. Over 2012–17, North America imported just over half of all quinoa in the world market (the United States imported 39 percent and Canada imported 17 percent). Various European countries account for much of the rest (29 percent), followed by Australia (4 percent) and various others (14 percent). At the peak price and volume in 2014, Bolivian quinoa exports reached US$200 million. With prices in the US$ 4,000 per ton range the following year, export revenue fell by half to approximately US$100 million; in 2016 prices declined to US$3,000 per ton and export revenue fell to US$60 million. Prices have not recovered, although some premium remains for organic *quinoa real*. Fair trade quinoa offers a significant premium captured by Bolivia, but it only accounts for 5 percent of the export market.

Logistics and chain management. Forty days are typically required for shipments to complete SENASAG inspection and export certification. This process could readily be streamlined. Improved coordination of shipping containers could reduce turnaround times from 10 days to 5. Improved rural assembly (*acopio*), sorting, and staging would significantly reduce post-harvest shrinkage (*merma*), which can be as much as 10 percent between farm and final shipment.

Strategy to improve competitiveness. To retain its comparative advantage and strengthen its position as a premier quinoa producer and prevent further losses of market share and profitability, Bolivia needs to resolve issues related to productivity and logistics. At the same time, it needs to pursue market strategies to expand market size, bolster prices, or partially hedge price risks.

Bolivian quinoa possesses fundamental advantages that must be consolidated as the foundation for a competitive value chain. Organic *quinoa real* is one such advantage. In addition to its marketing edge as an organic product, *quinoa real* has demonstrated nutritional advantages over conventional quinoa. An average 20 percent price premium existed for *quinoa real* as recently as 2015. This premium should be regained to the extent possible, but regardless, consumer loyalty to organic quinoa must be nurtured and this premium product should be differentiated and secured throughout the value chain, via improved traceability, to prevent Bolivia's comparative advantage from being squandered.

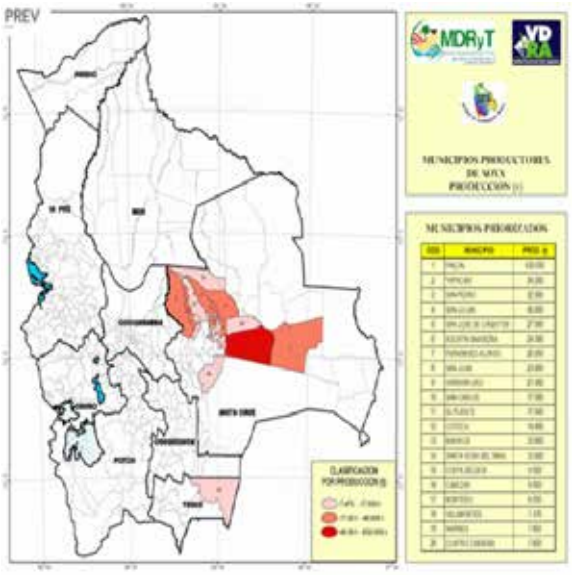
The Bolivian industry can work to expand market size and manage price risks. Bolivia, unilaterally or as part of an Andean regional effort, needs to invest in public-private efforts to expand the total size of markets for quinoa. Whether expanding existing markets or developing new ones (in Asia, for instance), the industry and public partners must carry out a sustained campaign exposing more consumers to quinoa and touting its "supergrain" or "superfood" benefits. Existing links between quinoa and high-end culinary options can be expanded in conjunction with tourism promotion and point-of-sale promotional materials in current and new markets. Bolivian industry strategy and communications should always differentiate between organic *real* and conventional quinoa.

The price received for exported quinoa is not entirely exogenous, given the small size of the world market and Bolivia's market share. Just as Bolivia and Peru share responsibility for saturating the market when prices peaked in 2014, so too can they avoid pitfalls without having to behave as a cartel. Joint Bolivia-Peru quinoa industry collaboration, or a broader Andean dialog that includes Ecuador, would be worthwhile to lower the risk of mutually damaging overproduction. In addition, the industry should focus on expanding Fairtrade opportunities as much as possible, given

the socio-economic profile of Andean smallholders and the potential of Fairtrade compared to current market prices.

SOYBEANS: Shifting the technological frontier and reducing the environmental footprint

Bolivia produces 3.2 million tons of soybeans on 1.2 million hectares, or one-third its cultivated area. This volume drives 10 processing plants to extract oil and separate the soybean cake. Exports go mainly to Andean neighbors, especially Colombia (42 percent). Soybeans also hold a strategic value as a feed or input source for poultry, livestock, dairy and other products, thereby generating domestic value. The expansion has been fueled by foreign capital (mainly Brazilian), as part of the broader expansion of oilseed commodities in the Southern cone.



Production and producer profile. As the seventh-largest exporter of soybeans, Bolivia captures only a very small portion of the market. The soybean value chain is Bolivia's most fully articulated value chain, encompassing a range of actors from production to processing. Producers rely on 43 firms to provide inputs, machinery, and services and sell to the 10 oil extraction plants linked to various internal and external marketing channels.

Production is centered in Santa Cruz Department but extends throughout the Lowlands Region. More than 14,000 farmers grow soybeans on farms of all scales. Although the industry claims that an average of 85 hectares is planted to soybeans per farm, in fact 77 percent of producers are small-scale producers (defined here as having 0–50 hectares), 21 percent are medium-scale producers (50–1,000 hectares) and 2 percent are large-scale producers (above 1,000 hectares). The best yields achieved in Bolivia are 80–90 percent of the yields obtained by other producers in the LAC Region, which limits competitiveness. Output volume grew by 163 percent over 2000–17. Over the same period yields increased by 54 percent to narrow part of the gap with regional competitors. Currently producers are looking to biotechnology to provide the highest-yielding varieties with the most favorable resistance profiles. The nitrogen-fixing property of soybeans helps to enhance yields of the crops with which it is rotated (often wheat, maize, sorghum, and rice), giving soybeans strategic importance for maintaining soil fertility in a country with the lowest rate of fertilizer use in the region.

Logistics and chain management. As a soybean exporter and landlocked country, Bolivia has a clear competitive disadvantage compared to neighboring countries with direct maritime access. Each link in the production and export chain is vulnerable to logistical inefficiencies. The average distance of farmers to the storage silos of soy processors is 100 kilometers, and storage facilities are 90 kilometers from the processing plants on average. Processed soybean cake is transported by rail from Santa Cruz to the river port on the Brazilian border, then barged along the Paraguay–Paraná Waterway to ships in Rosario, Argentina. The Bolivian government's military river port (Puerto Busch) in the tri-border area with Paraguay and Brazil

allows direct access to the Paraguay River and hence to the Paraná River and Atlantic.

Strategy to improve competitiveness. Bolivia's soybean industry is highly regulated. The export system permits exports only when domestic needs are satisfied, and prices are regulated through a system of price bands. Despite export and price controls, the subsector has grown as a value-added industry, and more than three-quarters of soybean exports are in the form of vegetable oil, flour, and soybean cake. The main competitive advantages for the industry lie in producers' access to inexpensive land, access to subsidized diesel, and preferential trade arrangements in the Andean Community market, the main market for Bolivian exports. These advantages are slowly eroding with the opening of the Andean Community market to competition in 2018 and the pressure to reduce diesel subsidies.

Export controls or other policy decisions that limit volumes in the export chain detract from the competitiveness of this subsector for several reasons. Unlike other products that are candidates for differentiation (such as quinoa, coffee, beef, horticultural, or food products), a true commodity such as soybeans competes based on costs and margins. Situated in a landlocked country, in the middle of the world's single largest soybean region, the Bolivian soybean industry and the government will need to pursue every opportunity within their control to reduce costs to become more competitive. The primary levers are increased productivity through genetic and technological improvements, water management, improvements in soil fertility and plant health protection, greater efficiency of SENASAG in its inspection and certification role, and any measures identified in the logistics chain to reduce costs. The analysis of productivity presented in Chapter 4 highlights important opportunities to increase productivity of small-scale producers and large ones. Efforts have been made by the government to level the playing field for small-scale soybean producers, however, with much less monitoring of the impacts of such efforts.

Growing as a sustainable industry. Bolivia has important opportunities to shift the soybean subsector toward a more sustainable pattern of expansion. Enhancing institutional capacities for land use planning and monitoring, as well as obtaining a stronger commitment from the private sector to promote responsible environmental and social investments and expansion, would deliver large dividends to valuable ecosystems and ensure the sustainability of the sector.

5.3. Take-away messages

A number of cross-cutting issues and recommendations emerge from the discussion of competitiveness constraints and opportunities in this chapter. They are highly relevant as Bolivia takes steps to further develop and consolidate agricultural value chains. These issues and recommendations are discussed in the paragraphs that follow.

The development and/or further consolidation of value chains in Bolivia would need a broad set of strategies to target opportunities in a range of markets. First, given the large number of producers involved in supplying domestic markets (Levels 1–3), it will continue to be a priority to enhance opportunities for creating wealth around domestic value chains. The size of these opportunities will largely be linked to domestic consumption and market developments, particularly the increased consumption of vegetables, fruits, legumes, and other products in the high-value spectrum, and further development of quality-differentiated markets through continued formalization of the retail sector, development of the gastronomic industry, and development of demand for fresh and locally produced food (short-value chains/*circuitos cortos*). In the most traditional sectors (such as potato), as well as in diversification into high-value products for domestic markets, success will depend greatly on developing competitive advantages around cost reductions, qual-

ity and productivity improvements, efficiencies along the value chain, and market integration, accompanied by improved capacity to manage risks (price fluctuations, climate shocks, pest and disease outbreaks, and so on). Second, in industrial commodity sectors serving domestic and/or export markets (soybeans, sugar, sorghum, and others), a strategy based on productivity improvements (for large-scale and small-scale producers) and cost-reductions is key, anchored in improvements in environmental sustainability and risk management strategies. Lastly, in the case of non-traditional agricultural exports, a cost-reduction strategy will help to increase participation in markets that are not highly quality differentiated (e.g. for beef in the Middle-East, China, but ensuring sanitary/safety compliance would be critical). Yet, important opportunities for Bolivia could be linked to strategies that take advantage of Bolivia's outstanding agro-diversity to develop products differentiated by their uniqueness and quality.

Bolivia is looking at markets such as India and China, which are highly price sensitive and competitive. The assessment of opportunities for agricultural exports to these markets must be based on a clear understanding of comparative and competitive advantages. In those markets, only a limited range of Bolivian products may be competitive on a cost basis, and therefore it may be relevant for Bolivia, in parallel, to develop and consolidate opportunities in markets that are more sensitive to quality.

The value chains selected for analysis in this report illustrate a broad range of targeted on-farm and off-farm investments that can enhance the performance of each value chain in response to market opportunities. These investments include improved varieties and inputs; the adoption of better production and management practices; improved equipment for production and processing; irrigation investments; and market promotion strategies and coordination platforms, among others. The effectiveness of these investments will depend greatly on the capacity to increase public and private capabilities for innovation—both "hard" and "soft" innovation capabilities. "Hard" innovation capabilities are related to research and development, and they include a range of technological opportunities linked to production, post-harvest handling, and processing, as well as opportunities for increasing resource and input use efficiency to protect the natural capital for agriculture (land, water, and biodiversity). "Soft" innovation capabilities include the generation of new inclusive business models (such as value-chain finance and product differentiation, certification, and traceability), as well as strengthening public-private dialogue and collaboration, not only within Bolivia but at the regional level, such as an Andean regional business dialogue to expand markets for quinoa or for other food and fiber products (potatoes, dairy, meat, leather). Public-private collaboration should proactively reach out to those in other countries who can assist with the transfer of technology and know-how. These innovation capabilities also extend to institutional development at the grassroots level, in terms of finding innovative ways and instruments to professionalize producer organizations. If these groups are not strengthened in concert with increased investments in irrigation and other assets and technologies, those investments will not achieve sustainable competitive levels.

Worldwide experience with developing inclusive value chains points to several factors that are critical for Bolivia to consider as it deepens efforts to develop its agricultural value chains. The relevance of innovation capabilities stands out among these factors, which include:

i. The most successful efforts responded to a market opportunity that was already in place or that could be developed.

ii. Participation of small-scale producers in dynamic value chains requires a strong level of collective action and coordination to achieve logistical and

cost efficiencies, ensure quality and scale in volume, and improve business and managerial capacities.

iii. When it comes to maintaining or enhancing quality and opening up market opportunities, production improvements are just as important as gains downstream in the value chain.

iv. Complementary efforts by multiple actors are needed, including not only value chain actors but also international agencies, NGOs, and public actors, whether they are closely coordinated or acting in parallel.

v. Leadership by an entity or set of entities providing strategic direction, including international projects/programs, research institutions, NGO initiatives, private sector associations, and/or government programs.

vi. Successful efforts took years to materialize, requiring persistence and a long-term vision.

It is the private sector that will move the needle toward greater competitiveness in all of the cases analyzed here and throughout the agricultural sector more broadly. But the private sector cannot contribute effectively to competitiveness without the critical support of an enabling environment for public goods and services.

As a landlocked country with a challenging topography across much of its 1 million square kilometers, Bolivia faces higher transaction costs than countries with maritime access and lower costs for transport infrastructure construction, operation, and maintenance. Whatever the budgetary level of infrastructure expenditures may be, either in infrastructure maintenance or construction, infrastructure investments should be prioritized within the logic of enhanced growth opportunities and chain coordination/connectivity.

Furthermore, streamlining logistics for agricultural exports and imports is a central cross-cutting priority. SENASAG is the key institution that inspects and certifies exports of agricultural produce and livestock and imports of agricultural inputs. Reducing delays and enhancing SENASAG's technical abilities to inspect and certify products will dramatically improve the efficiency of agricultural value chains while protecting plant and animal health. Furthermore, continue strengthening of INIAF and the agricultural innovation system more broadly is critical. The genebanks are remarkable and underutilized assets that would benefit from strengthening, most appropriately in collaboration with other genebanks in the region that are part of the network of the Consultative Group on International Agricultural Research and operate under the framework of the International Treaty on Plant Genetic Resources.

Important gains can also be achieved from broadening access to credit and increasing producers' leverage through alternatives to conventional financing. The EBA benchmarking reveals that Bolivia's regulatory framework provides relatively better access to financial services than the average for the region or countries with comparable income levels. The World Bank Enterprise Survey[31] corroborates that few businesses of any scale consider access to finance a major bottleneck. However, a large number of producers with market potential still have limited access to credit. One alternative to conventional financing is value chain finance, which includes supplier credit for buying inputs, to be repaid when produce is harvested and sold. Buyer credit operates similarly: a processor, exporter, or other commercial buyer advances funds tied to the delivery of a specific product. Additionally, Bolivia's introduction of the legal framework for Moveable Collateral permits the use of warehouse receipts, which enable producers or intermediaries with crops in storage to leverage the value of the in-

31 Enterprise Surveys. Bolivia 2017. Country Profile. The World Bank.

ventory as a guarantee, which in turn increases access to credit.

Buyer credit as a tool of value chain finance is an example of the potential to increase buyer-producer coordination, yielding cost savings and risk management for both parties. Business models that enhance opportunities for improved buyer-producer coordination should be explored and supported. The productive alliance approach, with which Bolivia has considerable experience, is an important step in this direction, but further opportunities for enhancing the role of the private sector in productive alliances should be explored.

6.

A policy framework for agricultural productivity and competitiveness

Photo: Programa de Alianzas Rurales (PAR), EMPODERAR

6.1. The policy framework for agricultural investment

The mid-2000s marked an important shift in economic and social policy priorities in Bolivia. The 2006–10 National Development Plan (NDP) of the Ministry of Planning and Development called for a new development paradigm and envisaged three major transformations: (1) a new productive matrix focusing on the redistribution of resources from the extractive industries toward other sectors of the economy to create wealth and economic diversification; (2) a new institutional framework placing communities at the center of decision-making related to productive activities at the local level, redefining community relationships with higher administrative levels (municipalities, regions, and central government); and (3) a territorial perspective, including the formation of regional territories as units of territorial planning based on associations of autonomous municipalities and the re-ordering of administrative units.

In alignment with the NDP, the National Strategy for Agricultural and Rural Development (ENDAR) prioritized family agriculture and sought to promote the social and economic inclusion of disadvantaged segments of the rural population. Increasing production and productivity were part of the strategy, but competitiveness and market integration were not explicitly mentioned. The 2010–15 Government Plan continued the general thrust of its predecessor, emphasizing the role of the public sector in stimulating economic diversification under the new development paradigm. The corresponding plan for the agricultural and rural sector (Revolución Rural y Agraria, 2010–20), reinforced the focus of policy making on smallholder agriculture, domestic markets, and the leading role of the state. It called for the development of strategic commodities, including coca, as well as Andean crops with high nutritional value (quinoa, amaranth, tarhui, chia, and so on), mainly with a focus on food sovereignty. The plan also emphasizes the key role of the state in integrating projects at the level of territories and providing direct transfers to producer and community organizations. Other priorities include expanding irrigation, mechanization, access to land, and activities of the State Agency for Agricultural Marketing (EMAPA) (providing seed and fertilizer to producers and purchasing and wholesaling agricultural produce). The plan also envisaged the strengthening of public institutions in the sector, including the deconcentrated and decentralized entities.

Under the Government Patriotic Agenda 2015 and the PDES 2016–20, the overarching development agenda of the government is still, by large, based on an economic model that emphasizes state-led public investment, but it is gradually opening to private investment in important areas. As discussed in Chapter 2, the PDES sets very ambitious goals to support economic diversification in agriculture and agribusiness, increase value addition and industrialization, and ensure food sovereignty. Its ambitious targets for the sector expected in 2020, include:

- Expansion of the area under production from 3.5 million hectares (2014) to 4.7 million hectares by 2020.
- Total annual production volume of 24.8 million tons, with specific targets for wheat, soybeans, maize, quinoa, tomatoes, potatoes, and coffee that exceed domestic consumption.[32]
- Expansion of the area under irrigation from 362,000 ha (2006) to 700,000 ha
- Significant yield increases (15–30 percent) in the main product categories (cereals, fruit, vegetables, oilseeds, roots and tubers, sugar, and animal feed).

32 Target volumes should exceed domestic consumption by ratios ranging from 8 percent (maize) to 136 percent (quinoa).

- Increasing the share of organic production to 10 percent.
- Increased participation of all producers in overall production.
- Promotion of integrated production systems and sustainable land management, including the restoration of degraded soil.

The Integrated Development Plan for the Agriculture and Rural Sector 2016–20 (PSARDI, its Spanish abbreviation) operationalizes the PDES for the agricultural sector. This plan identifies low levels of productivity and competitiveness as key constraints facing the sector. It recognizes that Bolivia is facing serious challenges in producing agricultural products that meet national and international demand in terms of costs, volumes, quality, and consistency of supply. It particularly recognizes the challenges facing small rural economic actors to compete successfully even in national markets. Low productivity is at the heart of the competitiveness problem, but it also affects poor consumers through higher food prices. The PSARDI recognizes the fundamental importance of developing integrated policies and actions that, based on the identification of competitive advantages for specific products, orchestrate and coordinate all actors along the value chain to capture market share and increase value addition.

The PSARDI identifies a lack of long-term entrepreneurial vision and commitment of all actors (public and private, as well as producer organizations) to work together within a common value chain framework. The main reasons for low productivity are well understood, in terms of limited technological innovation, low coverage of extension services, limited access to financial services, difficulties in agricultural marketing, food safety problems, inadequate production infrastructure, and weak producer organizations that lack entrepreneurial vision and capacity, among other factors. A further important weakness is weak coordination among different public entities in the agricultural sector at the central and subnational level, and between the Ministry and subordinate entities. Despite its emphasis on import substitution and food self-sufficiency, the PSARDI recognizes the limitations of domestic markets for agricultural development, given their limited size and purchasing power. It calls for increased efforts to enter export markets, making use of preferential market access granted by a number of Bolivia's trading partners.

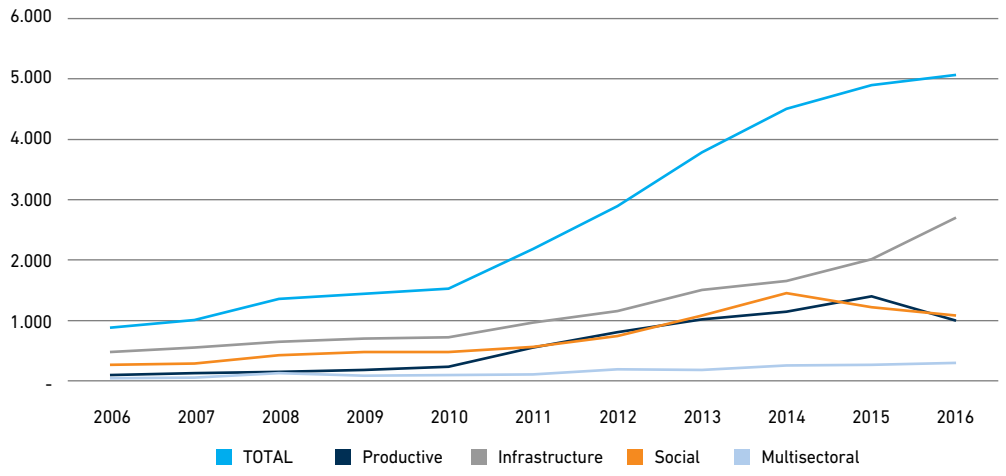
The PDES emphasizes productive complexes (PCs) as a key approach to diversify the structure of production, promote value addition and industrialization, and achieve food security and self-sufficiency as well as selective integration into export markets. The PCs are conceived as economic clusters composed of different productive actors (public, private, cooperative, and other social enterprises) which bundle the provision of support services, productive infrastructure, and research and technology.[33] PDES envisages spending US$ 8.4 billion on developing the PCs through 2025 (approximately US$700 million per annum).

6.2. Broad patterns of public spending on agriculture

Historically, the share of agriculture in overall public spending has been low, averaging 1.5 percent between 1996 and 2008 (World Bank 2011). Since 2006, revenues from the extractive industries have been redistributed across economic and administrative units to develop productive sectors, including agriculture and related activities. Figure 34 shows overall trends in public expenditures between 2006 and 2016 by economic sector. It reveals a fivefold increase in the

33 PDES envisages the development of 21 PCs, of which 12 will focus on agricultural and forest products, 2 on agricultural inputs (seed and fertilizer), and another 2 will be linked to agricultural raw materials (textiles and leather). The PCs will have facilities across the national territory.

Figure 34. Public investments executed by economic sector, in USD millions



Source: Estimations based on INE data

overall volume of budget executed. The largest share of the budget went to infrastructure, showing constant growth throughout the period. During the first five years, social spending was higher than spending for productive sectors (including agriculture), but since 2011 expenditure levels between these categories has levelled out. Public spending in the productive sectors increased at a constant rate, especially from 2010 onward, to peak at approximately US$1.4 billion in 2015. In 2016, spending for productive sectors decreased, despite a continued increase in overall budget execution.

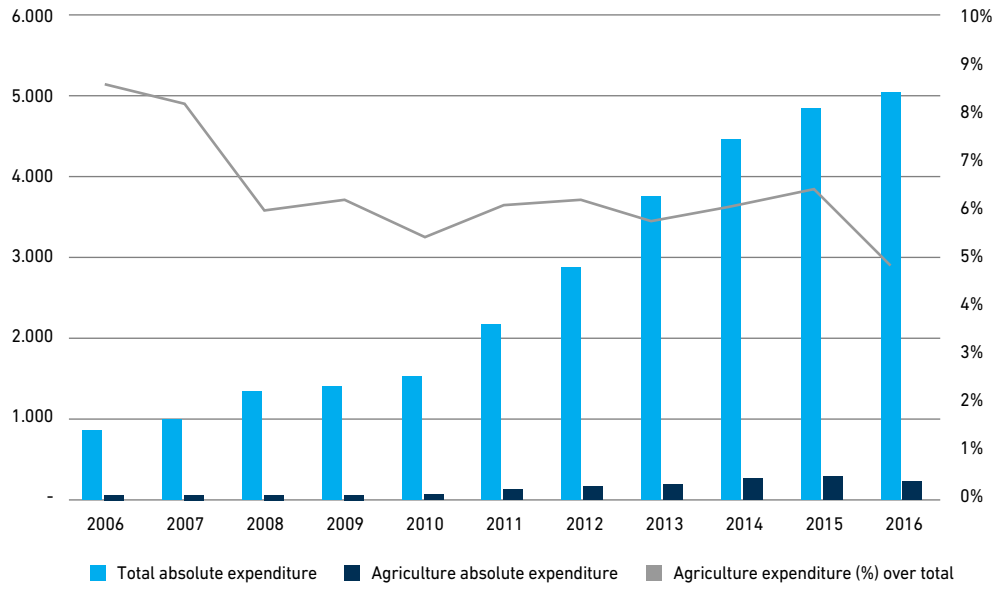
Figure 35 shows estimated overall public expenditure and the public expenditure on agriculture between 2006 and 2016. The share of agriculture in total expenditures declined slightly, falling from 9 percent to 6 percent between 2006 and 2008. Between 2008 and 2015, a period of strong fiscal expansion, the share of public expenditure dedicated to agriculture remained at around 6 percent, followed by a slight decline in 2016.

These statistics provide an incomplete picture of total budget support to agriculture and do not include co-financing of national programs by the subnational entities, which are not reflected in the stream of budget execution. Nor do they include expenditures under the Ministry of Productive Development for the establishment of PCs and for EMAPA. The budget of EMAPA in 2018 was US$182 million, of which US$113 million was executed.

6.3. Agricultural sector enablers

In recent years, the Bolivian government has made significant investments in the provision of public goods and services linked to food production. The main programs strengthening the enabling environment for agriculture are linked to investments in land administration, plant and animal health and food safety, agricultural innovation and technology development, and irrigation infrastructure. Several of these programs are implemented by so-called deconcentrated institutions under the MDRyT, which have a specific mandate in the respective subject area. Important institutional reforms occurring over the last

Figure 35: Total public expenditure and agriculture expenditure, in USD millions.



Source: Authors, based on INE data

15 years have included the creation of EMAPA (2007), the National Institute for Innovation in Agriculture and Forestry (INIAF) (2008), and the National Agricultural Insurance Institute (INSA) (2011).

6.3.1. Land rights and land management

Greater land tenure security encourages productive investments on the farm and facilitates access to finance. It is an important element for improved productivity and competitiveness. The information available for Bolivia highlights the success of laws and policies for land reform, registration, and titling (Box 3). The National Agrarian Reform Institute (INRA) reports that land tenure in Bolivia was structured as follows in 2017: peasant and intercultural communities have a 21 percent share; Community Lands of Origin (TCO) and Indigenous Community Lands (TIOC) have a share of 23 percent; fiscal/state land represents 25 percent; land pending "clean" titling represents 21 percent; and medium and large entrepreneurial land represents 10 percent. Although the government has been working on addressing persistent challenges with regard to the unequal distribution of land and fragmentation of arable land, the lack of consistent reporting over the years regarding the land awaiting "clean" titling and being titled (where, and to whom) makes it difficult to understand land distribution patterns and the extent of the current conflicts in land ownership in Bolivia. Increasing concerns are also emerging regarding land grabbing and trafficking on fiscal lands, indigenous territories, and national reserves, calling for stronger land registration systems and a greater overall need to continue strengthening INRA's institutional capacity. Furthermore, Bolivia faces a significant challenge in terms of sustainable land use, leading to increasing deforestation and land degradation. This challenge is discussed in detail under Chapter 7 (Section 7.2) of this report.

Box 3. Secure land tenure to promote agriculture investment

Access to agricultural land was addressed for the first time with the Agrarian Reform Act of 1953, which mainly affected properties in the Highlands and Inter-Andean valleys, where the majority of large estates were located at the time, and where the peasant population was most concentrated. The reform distributed about 600,000 farms on 25–30 million hectares in the Highlands. Settlement programs between 1958 and 1985 distributed 3–5 million hectares in northern Santa Cruz, the Chapare region of Cochabamba, and the region of the Alto Beni to settlers, most of whom came from highland areas. Despite the achievements in breaking up the traditional haciendas, there was a resurgence of land concentration and lack of access to land in eastern Bolivia between the 1960s and 1990s. During this period, successive governments made large land grants, primarily in Santa Cruz, Beni, and Pando, of nearly 30 million hectares. This area has been the land base for the expanding livestock sector the boom in soybeans, wheat, sugarcane, and rice in Santa Cruz, making it the wealthiest area of Bolivia but also the most unequal.[34]

The second reform, the Agrarian Reform National Service Law of October 1996, sought to make land ownership more equitable, secure, and sustainable, but the results were not as expected. Projected to solve land tenure in 10 years, in practice the National Agrarian Reform Institute (INRA) was slow, cumbersome, not very transparent, and expensive, and its results were rather poor.[35]

A new framework was provided by Law 3545 on Community Reconciliation of the Agrarian Reform of 2006, approved by a referendum in 2009. It opened the possibility of forming indigenous territorial autonomous entities and allowed communities to conserve customary land use, control the territory, and exercise self-government. Since then, significant progress has been made in regularizing land titles and property rights.[36] INRA reports that during 1995–2014, 75 percent of the country's rural properties were titled (70 million hectares and almost 650,000 titles).[37] Most recent statistics by INRA indicate that in 2017 the cumulative figure reached 80 percent. The remaining area to be covered compromises 20.1 million hectares, of which one-third presents some kind of ownership conflict. About 36 percent of the more than 8.5 million hectares of state/fiscal land awaiting a "clean" title or titling has already been distributed, and the remaining 64 percent is in the processes of being distributed. A large proportion of the land awaiting a "clean" title or titling belongs to small-scale farmers (defined as farmers with less than 2 hectares in the Highlands Region and 50 hectares in the Lowlands Region). INRA also established a cadaster information system. The government has benefited from multilateral funding to undertake these reforms since 2002, with planned investments until 2022.

34 World Bank, Bolivia, Public policy options for the well-being of all, 2006.

35 Instituto Nacional de Reforma Agraria (INRA), breve historia del reparto de tierras en Bolivia, De la titulación colonial a la reconducción comunitaria de la reforma agraria: Certezas y proyecciones, 2008.

36 Under Law 3545, as of 2012, land rights had been formalized on 61 percent of the land in rural areas (24 million hectares) . Source. Universidad Mayor de San Andrés. Facultad de Ciencias Económicas y Financieras, Instituto de Investigaciones Económicas, Efecto de la implementación de la ley 3545 en el derecho propietario, La Paz, 2014.

37 International Development Bank (IDB), Bolivia, Programa de Saneamiento de Tierras II (BO-L1113)

6.3.2. A framework for agricultural innovation

An important institutional innovation introduced in Bolivia was the establishment of INIAF in 2008 as the governing and coordinating body of the National Agricultural and Forestry Innovation System (SNIAF, Spanish acronym). This institutional framework provided an opportunity for the government to resume its leadership in the development of science and agricultural technology and rural extension. Government funding to consolidate SNIAF (including INIAF)was complemented by funding from various bilateral and multilateral organizations, including the World Bank PISA project (2011–17, US$55 million, including government contributions).

This support made it possible to strengthen INIAF's strategic research programs substantially by upgrading infrastructure, hiring staff, and funding a larger operating budget. Infrastructure to modernize agricultural experiment stations (upgraded to innovation centers), genebanks, seed testing laboratories, and seed conditioning plants was accompanied by improved procedures for planning, implementing, monitoring, and evaluating research, resulting in many operational efficiencies. INIAF's technical assistance programs were also strengthened so that INIAF could increase its presence at the departmental level and interact more closely with target groups and relevant stakeholders in the agricultural innovation system. Procedures for planning, implementing, and monitoring seed certification processes were overhauled and to a large extent automated, allowing the INIAF Seed Directorate to achieve major operating efficiencies even as it significantly scaled up.

More than 10 years on, this framework for agricultural innovation—a major enabler of agricultural productivity and competitiveness—has weakened dramatically. Even though INIAF is a strategically important institution for Bolivia, it has virtually no operating budget to undertake agricultural research and transfer technology to producers. Under PISA the annual expenditure was BS 1.5 million; now the annual budget spent by INIAF is BS 150,000. The institutional base can hardly be stable when 90 percent of the staff is temporary (operating through a series of 3 3-month contracts) and highly transient. The most significant challenge is that technology transfer is stalled owing to the lack of funding; virtual training and training of trainers in the departments and municipalities is being explored as a cheaper option.

6.3.3. Oversight for plant and animal health and food safety

SENASAG is a deconcentrated public entity responsible for plant and animal health and food safety in Bolivia. A succession of loans from the Inter-American Development Bank (2010–22, US$125 million) is enabling SENASAG to narrow its capacity gaps and strengthen its operations, particularly through investments in laboratory facilities and the prevention of animal diseases. At the same time, this lending does not place much emphasis on narrowing capacity gaps in key areas such as "sanitary diplomacy"[38] and the efficiency of SENASAG procedures and services. This agenda is increasingly relevant, however, to the government's interest in an export strategy directed at new markets in China, India, Russia, and markets with more stringent and complex entry requirements.

6.3.4. Access to key infrastructure and technology: Irrigation and mechanization

As of October 2016, Bolivia had 7,121 irrigation systems, covering about 387,377 hectares. Irrigation is a key determinant of agricultural productivity, resil-

38 "Sanitary diplomacy" can be described as efforts to develop consensus on food and agricultural safety and health standards that will facilitate the international movement of agricultural and food products.

ience, and improved income. Bolivia has made enormous efforts to expand irrigated area since 2006. The PDES target is to increase the area under surface irrigation to 700,000 hectares, which is nearly double the current area. To support that objective, the government, mainly through the Ministry of Environment and Water (MMAyA) and its Vice Ministry for Water Resources and Irrigation (VRHR), has implemented a series of programs with its own funding, multilateral loans, and technical assistance from bilateral donors. For example, the National Irrigation Program with a Watershed Approach (PRONAREC) (2009–21, total investment of US$90 million in its phase, it is expanding considerably in its third phase (US$154.8 million), which runs until 2021. Other programs coordinated by VRHR through a watershed approach are the MI RIEGO, financed by the Andean Development Bank (CAF),[39] the Subprogram of Investments in Inter Communal Irrigation (SIRIC, Subprograma de Inversiones en Riego Inter Comunal), funded by the German cooperation; and the Climate Resilience-Integrated Basin Management Project (2014-2020), funded with multilateral funds from the World Bank.

A program established in 2017 under MDRyT—"Our Well" (Nuestro Pozo)—focuses on installing wells[40] in all municipalities with agricultural production and livestock to ensure that water is available for food security. For the local contribution, the MDRyT signs inter-institutional cofinancing agreements with lower-level government entities. The government has also been promoting the expansion of pressurized on-farm irrigation systems ("technified irrigation") through programs such as Productive Alliances, with investments in on-farm irrigation estimated at US$75 million, managed by EMPODERAR/MDRyT. It is estimated that during 2012–17 the government invested about US$432 million (from current budget and through external loans) in the establishment of 83,236 hectares of newly irrigated land.

Farm mechanization has also been a focus throughout Bolivia since 2006. Mechanization increases production and labor productivity but can also enhance land productivity by ensuring that farm operations are performed at the right time, which is increasingly important in the context of climate change. The Unit for Productive Infrastructure, Local Technology and Mechanization (UIPTLyM, Unidad de Infraestructura Productiva, Tecnología Local y Mecanización), under the Vice Ministry of Rural and Agricultural Development, is responsible for mechanization programs. Producers gain access to machinery through two channels: credit and grants.

Legislation issued in 2016[41] gives the State responsibility for strengthening the agricultural production capacity of the 339 autonomous municipal governments and facilitating access to agricultural mechanization to contribute to food security with sovereignty. To achieve this objective, the Program for Municipal Service Centers in Agricultural Mechanization[42] was created in 2018, with a budget of US$35.2 million (Bs 243,000,0000)[43] financed through resources from the national treasury.

39 MI RIEGO aims to achieve sustainable increases in the agricultural incomes of rural households participating in the program by expanding the agricultural area under irrigation and improving water-use efficiency and distribution for agriculture. The program is implemented in seven departments (Cochabamba, Tarija, Chuquisaca, Oruro, Potosí, La Paz, and Santa Cruz) where community irrigation subprojects with a watershed approach will be cofinanced.

40 Nuestro Pozo, Programa Nacional de Perforación de Pozos de Aguas Subterráneas, established through Supreme Decree N° 2852.

41 Law No. 786 of March 9, 2016.

42 DS N ° 2785 of June 1, 2016 and DS N ° 3709 of November 7, 2018.

43 Additionally, Bs 38,890,080 for the payment of customs taxes for the import and storage of machinery, equipment and agricultural implements in customs areas.

For a five-year period starting in 2011, tariffs were reduced to 0 percent on imports of agricultural machinery and equipment (plows, mowers, machinery for food preparation) and some agricultural inputs (seed, cattle feed, vaccines, and veterinary medicines). In 2016 this measure was extended for another five years.

6.3.5. Trade and domestic price policies

The overall policy to ensure food sovereignty has embraced important market-related policy interventions, including trade policy, domestic price measures, and the creation of state enterprises, as briefly discussed below.

Regarding agriculture and food imports, the tariff protection given to the agricultural sector is higher than that for manufacturing. In 2017, the average tariff applied to agricultural products (13.3 percent) was higher than the tariff applied to non-agricultural products (10.8 percent) (WTO 2017).

Perhaps the most controversial measures have been on the export side. As noted, the government introduced export controls in 2008, when it prohibited exports of a range of agricultural products that were considered important to food sovereignty.[44] Most of those prohibitions were later replaced by the introduction a quota system for key exports. The government can also apply temporary tariffs and export restrictions on specific products, when relevant from a food security perspective. A domestic supply and fair price certificate (CAIPJ) and an export license or permit are required prior to exporting agricultural products. The CAIPJ verifies that domestic production meets domestic market demand and that there is an exportable surplus.

Export licenses and permits are used to regulate exports of some products, such as sugar and by-products. Again, the export licenses are issued only if a surplus exists and, in the case of sugar, if the mandatory buffer stock, equivalent to two months of domestic consumption, has been built up. The government's trade and market-related interventions are largely the responsibility of the Ministry of Production Development and the Plural Economy (MDPyEP). Exports of some agricultural products benefit from the customs drawback procedure, which refunds all or part of the customs duty and other taxes paid by the exporter on the inputs and other materials incorporated into the exported goods.

Price bands are applied to some products that are also subject to export restrictions, such as soybeans and rice. For soybean by-products, since 2011 domestic prices have been set according to the requirements of domestic supply, and the domestic price rises as domestic supply needs are fulfilled. Given the global decline in soybean prices, the industry has been advocating for the elimination of export quotas and price-related interventions. Currently, the export quota for soybeans is set at 300,000 tons. In May 2019, the government announced the expansion of the export quota, allowing exports of up to 60 percent of total production.

An assessment of the effectiveness of the overall trade and domestic price policies in agriculture in Bolivia is beyond the scope of this report. Early work by FAO and others demonstrated that price stabilization efforts in several countries, including Bolivia, through direct state interventions in the market, were rather costly and difficult to manage, and often led to adverse outcomes for agricultural producers.[45]

44 Live bovine animals, fresh bovine meat, chicken meats, wheat and wheat flower, corn, rice, and vegetable oil.

45 FAO, 2014. Policy responses to high food prices in Latin America and the Caribbean. Country Case Studies.
Schuttel, C.; Kleinwechter, U.; Ihle, R.; Grethe H. 2011. Domestic policy responses to the food price crisis: The case of Bolivia. Journal of Agriculture and Rural Development in the Tropics and Subtropics. Vol. 112 No. 2 (2011) 125–139.

Furthermore, the most recent assessment of the impacts of Bolivia's quantitative restrictions on exports,[46] particularly beef, show that these restrictions had a negative impact not only on total production but also on production for the domestic market. In February 2008, the government banned exports of beef as well as other products such as maize, sugar, poultry, and rice. Unlike other products, for beef the prohibition on exports was not relaxed until March 2012, when Bolivia imposed a quota system that allowed producers to export beef one the domestic market cleared. Although the export restriction was expected to reduce the domestic price of beef, the domestic price of beef continued to rise, even faster than the international beef price.

The Bolivian authorities are currently applying a less restrictive trade policy with respect to exports. For example, although export quotas persist, they have gradually increased, and the domestic supply and fair price certificate (CAIPJ) is no longer required for most products. There are a few exceptions; for instance, exports of wheat and wheat products are banned.

In addition to import and export interventions, in Bolivia the state is expected to play an important role in agriculture and food processing, particularly through direct participation in production and processing and purchasing of local output at fair prices to the producers and the sale of these products to consumers. The authorities consider that public enterprises complement private Bolivian or foreign economic actors. In the mining/hydrocarbon sector, public enterprises retain a significant share of trade, particularly exports. In the agriculture and food sector, although state enterprises operate in the sugar, dairy, seed, and fertilizer industries, their share in their respective markets is relatively low.[47] Although it is unlikely that these state enterprises in have the power to influence agricultural prices and markets (WTO 2017), they can discourage private sector investment in the sector. In the case of the production of fertilize the public sector in Bolivia is expected to have an important impact on agricultural productivity through the production and supply of urea, and a national urea production plant established a few years back is expected to supply an important share of the national demand and supply regional markets. In fact, urea exports have grown, and Bolivia is currently exporting product to Brazil, Paraguay, and Uruguay. The effects of the public production/supply of fertilizer on the overall input price and productivity remain to be seen, and they need to be closely monitored to understand the real impacts.

The gains achieved so far in modernizing the agricultural trade and market policy framework in the present decade (such as the increases in export quotes) have being the result of pressures from the private sector. Those pressures are gradually intensifying as Bolivia encounters a more complex international trade environment and as margins in supplying the domestic market are increasingly narrowing. Close coordination and collaboration between the government and the private sector in Bolivia will be critical to ensure that the most effective policies are in place to support improved competitiveness of agricultural producers and enterprises, while protecting the well-being of urban and rural consumers.

46 (1) Garcia, E; Rossio, M; Stucchi, R. (2017). The impact of export restrictions on production: A synthetic controls approach. December 2017. (2) Burgoa, R; Herrera, A. 2016. El efecto de las restricciones a la exportación de carne bovina sobre la producción y oferta doméstica. Published in the Bolivian Central Bank website.

47 Empresa Azucarera San Buenaventura has a 1.26 percent share of the sugar market, while the Empresa de Lácteos de Bolivia (LACTEOSBOL) has a 4 percent share of the dairy market. Likewise, the Empresa Pública de Abonos y Fertilizantes, which imports and markets fertilizer, imports a volume equivalent to 1.29 percent of demand, and the seed output of the Empresa de Semillas represents 1.88 percent of domestic production (Word Trade Organization. Trade Policy Review Bolivia. September 2017).

6.4. Building farm and value chain capabilities

Complementing investments in the enabling environment, a second set of investments directly support production and productivity of rural producers and their organizations (see Annex 3). In line with overall government policy, most of these programs/investments have mainly targeted poor and marginalized producers and communities, often located in remote areas with high levels of poverty and vulnerability. Consequently, market integration and competitiveness have not been an immediate priority. Most of this support has focused on production—the enhancement of on-farm assets and technologies and the provision of seed capital and technical assistance. A small subset of these investments has a clear market-orientation and focuses on strengthening market linkages.

Only few projects target the more entrepreneurial segments of the smallholder population with a higher capacity for market integration. The Productive Alliances Project stands out in this regard; for producer organizations to receive project support to finance their business plans, they were required to establish a link to a buyer. Even so, project support focused on primary production and productivity, and the producer group linked only with the immediate buyer, often an informal trader who already had a longstanding relationship with the producer group. No specific support was provided to strengthen off-takers or other downstream players and remove downstream bottlenecks that could sizably affect producers.

Commitments to support smallholders through seven programs over 2006–22 (excluding investments through the Indigenous Fund and FONADIN) are approximately US$525–540 million (Annex 3). Many of these programs have ended or are ending in 2019, however, with the exception of the Direct Support for the Creation of Rural Agri-food Initiatives (CRIAR II) project, Productive Alliances (PAR II) project, and Pro-Camelidos project. A total of 461,711 beneficiaries are or will be reached through these investments. This figure does not include past investments and beneficiaries of the defunct National Indigenous Fund or those expected under the New Indigenous Development Fund (FDI) that runs until 2021 (and is expected to reach nearly 300,000 beneficiaries). Nor does it include those reached through the National Fund of Integral Development (FONADIN).

The evaluations (including impact evaluations) carried out for some of these programs/projects have reported important positive results in terms of production and yield increases, and household impacts at the income level. Important lessons can be identified from Bolivia's experience and similar experiences in the region, which are relevant to the government as it explores new/complementary approaches to support small-scale producers, particularly within the context of developing value chains. The following paragraphs represent an attempt to summarize those lessons and translate those lessons into opportunities to enhance the effectiveness of the support to small-scale farmers in Bolivia.

Table 20 summarizes current efforts to enhance the productive capacity of smallholders and proposes some shifts and complementary approaches to enhance the effectiveness of this support. The discussion that follows the table highlights these opportunities for pursuing complementary approaches or strengthening current efforts.

Broaden intervention entry-points to reach other value chain actors

Most of the government programs for agriculture discussed here channel support through producer organizations or other venues for collective action by farmers and communities. As noted, however, the role of other key actors such as aggregators, buyers, and industry associations is often overlooked. As men-

Table 20. Current and enhanced approaches to support smallholder competitiveness

Area	Features of current smallholder support	Desired enhanced aspects
Intervention target	- Capacity strengthening of producer organizations (POs) to enhance market access/ linkages	- Create capacities a different value chain levels (organized producers and other key value chain actors: processors, aggregators, service providers, input providers, buyers)
Approach	- Demand driven (by POs)	- Demand driven+ identification of opportunities (geographical and in value chains/subsectors)
Intervention focus	- Productive efficiency	- Productive & logistic efficiency + resilience + sustainability
Intervention content	- Services: AT+ in very few cases financial services - Grant financing: for inputs+ capital+ productive assets - Skills & Knowledge gaps via training.	- Strengthening internal capacities of POs but also other value chain actors, via a combination of approaches: skills development, facilitate access to key services and input markets. Tranversal: use of digital technologies.
Vertical linkages/ coordination	- As given (producer-buyer linkages)	- Promoted/facilitated, active role of buyers/ private players.
Horizontal linkages	- Strengthening POs, but few consolidation of lessons on effective approaches	- Promotion of production clusters/networks to ensure aggregated impacts territorially.
Focus of the upgrades supported	- Largely product upgrades (focus on on-farm/ POs investments)	- Focus on value generation (combination of product, functional, process, and market upgrades). Focus on on-farm and off-farm investments along the chain.
Private sector role	- Generally a passive or very limited role	- More active role of the buyer (private sector)
Common enablers	- Rarely	- Multi-linkages and coordination of investments (roads, electricity, financing)
Sectoral enablers	- Generally not considered	- Links to enhanced policy & regulatory frameworks and institutional capacities.

tioned in Chapter 5, most of the successful experiences with inclusive value chain development worldwide are anchored on integrated support—in other words, they target several intervention points to address productive and competitiveness issues throughout the value chain. They also often include a strong platform for leadership, coordination, and strategic priority setting for the value chain. Such platforms bring a broad set of institutions and other stakeholders to the table (for example, public-private coordinating platforms or innovation platforms). Through these platforms, support currently provided through grants to producer organizations can be easily linked to ongoing or proposed value chain strategies. Without such platforms for strategic priority setting and coordination, the risk of fragmented or overlapping investments is high, and there are few possibilities for understanding the aggregate benefits at the value chain/subsectoral level of investments made through grants and other services.

Furthermore, most of the investments have been implemented using a demand-driven approach, which has been instrumental for generating ownership and empowering communities and producer organizations. However, this approach would need to be complemented with targeted more strategically investments around subsectors (products/value chains), to generate aggregated impacts.

Systematically build capacity among producer organizations

Although most investments are channeled through producer organizations, and although most programs seek to strengthen the capacities of producer organizations, little is known about which approaches are most effective. Significant gains could be generated by sharing experiences of working through producer organizations and building consensus on the most effective ways to enhance their capacity. Under the Productive Alliances project (PAR II), an interesting approach is being developed. Lessons from that experience should be systematized and disseminated widely. Some tools and instruments for assessing the capacity and performance of producer organizations[48] are coming into wider use throughout the world. They can be customized to enhance efforts to build capacity in producer organizations and can also be applied more broadly to organizations and businesses across the agricultural sector.

Strengthen service providers, as part of the agricultural innovation framework

As part of the support provided to farmers, demand-driven programs often include a set of services that can range from advice and guidance in the identification, preparation, and implementation of proposals, to technical assistance, extension, and training. It is generally assumed that capable service providers will always be available and that they will provide services at the right time, but often this assumption is incorrect. Service providers may need training and capacity building as part of an integrated approach to support the improvements demanded by smallholders. This should not be seen as a strategy to be carried out by individual programs and projects alone, but rather as part of a broader strategy to build a strong innovation system by building capacity in public and private actors aside from farmers, including extension service providers.

Seek opportunities for digitizing agricultural services

Digital solutions in the so-called "last mile" of agricultural value chains have numerous advantages and applications. They help to maximize operational efficiencies, promote financial inclusion, empower individual by making transactions more transparent, reduce travel times and transaction costs, and support information dissemination and traceability. There are important opportunities for these solutions to revitalize extension services and other services for farmers, increase program efficiencies, and enhance supply chain coordination.

Enhance the role of the private sector and strongly support a market orientation

The production approach that has dominated development support to smallholders in Bolivia would benefit from a stronger market orientation. The development of supermarkets, agroindustry, and other formal market outlets may be moving more slowly in Bolivia than in other countries in the region, but opportunities nevertheless exist to link farmers to market developments. The emerging gastronomy value chain and export markets both present options for participation by small-scale producers. The development of such opportunities will entail close collaboration with the private sector and enhanced coordination and collaboration with all participants in the value chain. Especially in export markets, strategies to support "sanitary diplomacy" and export promotion will need to be closely aligned.

48 An example of such is Scope Insight https://www.scopeinsight.com/, which is increasingly mainstreamed through development programs.

Promote linkages to financing interventions

An additional opportunity to explore is to improve the complementarity of grant funds with financial services and credit schemes to expand the mid- and long-term impacts of these programs. PAR II is supporting initial efforts to enhance financial literacy and improve producers' links to financial services. The lessons emerging from these efforts need to be properly systematized and disseminated.

Seek the convergence of programs and investments

Initiatives to promote the development of small-scale agriculture sometimes end up operating in silos, oblivious to other ongoing programs and projects that offer potential synergies. Policy makers and program administrators need to better understand the "big picture" and pursue complementarities with other initiatives. Furthermore, the setting of robust and integrated monitoring systems around these cofinancing investments is a critical area requiring government attention. Under PAR II, a first-class monitoring and reporting system has been developed and could serve as a good foundation for a broader and more integrated monitoring and reporting system for the sector.

Seek convergence with key enablers in the agricultural sector

The combined impact of programs to improve smallholder productivity in Bolivia could be enhanced by aligning the opportunities for agriculture and agribusiness with key enablers in the agricultural sector, such as research and innovation systems, sanitary and phytosanitary programs, and efforts to expand irrigation, mechanization, and land titling.

Seek convergence with common enablers in the wider economy

Better alignment of agricultural investments and programs with the common enablers of growth and competitiveness in the wider economy will increase their impact. A better understanding of regional and local opportunities for agricultural investment will facilitate better planning and help to tailor incentives and support to make the most of those opportunities. The capacity for planning should be strengthened and incorporate methodologies for identifying the areas that offer the greatest agricultural potential with low environmental impacts, and where agriculture can make an important contribution to economic growth and poverty reduction. Through this kind of planning and priority setting, efforts at the farm level can be aligned with key enabling investments, such as investments in infrastructure (roads, electricity, internet connectivity, and so on).

Seek opportunities to strengthen climate-smart practices and support better nutrition

Climate change and nutrition are important cross-cutting aspects of efforts to build farm and value chain capabilities. As the next chapter will discuss in detail, climate shocks (as the name implies) are major disruptors of any sustained pattern of agricultural improvement. The Government of Bolivia is proactively supporting approaches to adapt to climate change and opportunities to make agriculture less vulnerable to climate disruptors. It can achieve even more if climate-related investments are mainstreamed across the portfolio of agricultural investments. The same mainstreaming approach is valuable for nutrition; for example, it will facilitate opportunities to link agricultural investments with nutrition education and to pilot approaches that incorporate nutritional considerations in agricultural interventions.

7.

Sustaining Productivity and Competitiveness Gains

Photo: Shutterstock

This chapter looks to the future to understand how gains in agricultural productivity and competitiveness might be protected from the risks that accompany climate change and from cycles of worsening environmental degradation. It looks at the production risks and potential losses that Bolivian agriculture could experience through climate change and at government efforts and other approaches to counter those risks. The second part of the chapter focuses on strategies for reducing the environmental footprint of agriculture, not only to preserve the resource base for agriculture but to mitigate the effects of climate change.

7.1. Climate risks and the future of Bolivian agriculture

The agricultural sector in Bolivia is exposed to a variety of risks related to production, markets, or the regulatory environment. Shocks related to price and climate are the most obvious and are often intrinsically linked. Bolivia's geographical and socioeconomic characteristics and low institutional capacity to mitigate climate risks make it highly vulnerable to the impacts of climate change. Throughout the Andean region, Bolivia is recognized as the country where the impacts of climate change may have accelerated most rapidly. During the last 50 years, the country has lost approximately half of the surface area of its mountain glaciers. Higher projected temperatures and rainfall during the rainy season will expose the country to prolonged dry periods and an increase in the frequency and magnitude of floods, landslides, and other weather-related events (World Bank 2013; WRI 2017).

Bolivia is already experiencing the effects of greater climate variability and more extreme climate events. The Global Climate Risk Index (CRI) 2018[49] ranks Bolivia 25^{fth} of 178 countries in terms of the impacts of climate-related hazards during 1997–2016. In 2016, Bolivia was among the top 10 countries regarded as most highly affected by climate-related events.[50] About 74 disasters have been recorded between 1900 and 2017.[51] Droughts and floods jointly account for roughly 97 percent of the total number of affected people. Most of these events are influenced by El Niño (more properly, the El Niño Southern Oscillation, ENSO).

Agriculture (including livestock production) is inextricably linked to climate and weather, and worldwide it is highly vulnerable to climate change. Climate change scenarios for Bolivia reveal patterns of increasingly variable rainfall and a greater incidence of drought, which have important implications for quinoa, maize, soybean, and potato production systems (Box 4). Scenarios predict that crop yields will decline (up to 40 percent for maize and soybeans) owing to water shortages and hot spells during critical crop growth stages.

49 The Global Climate Change Risk Index, developed by Germanwatch, analyzes the quantifiable impacts of extreme weather events, both in terms of fatalities and economic losses, based on data from the *Munich Re* NatCatSERVICE.

50 The most catastrophic disasters, including floods, droughts, and landslides, accounted for US$3.1 billion in damages over a 35-year period (1982–2016) or US$91.1 million on average per year.

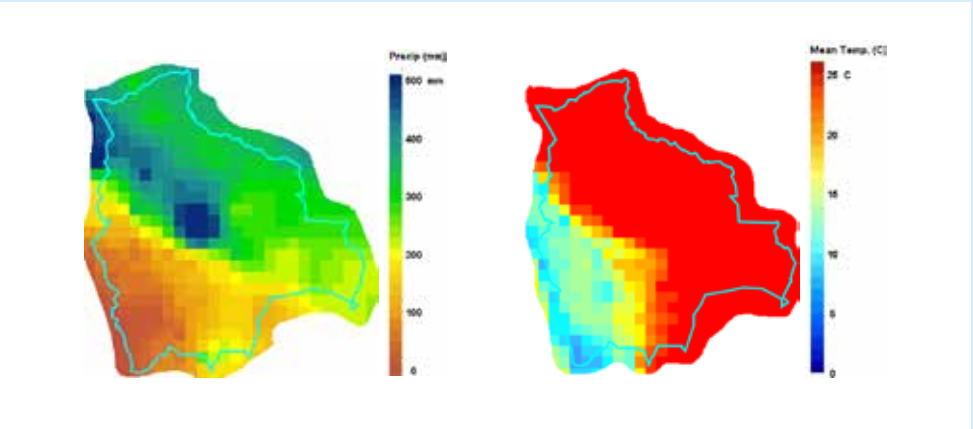
51 The number of natural disasters increases up to a total of 89 if earthquakes (03 disasters) and epidemics (12 events) are included. International Disaster Database (EM-DAT).

Box 4. Anticipated effects of climate change

The direct effects of climate change in Bolivia are manifold, with substantial variation across sub-regions. In the Andes, sustained glacial recession has been documented in the last 50 years, especially since the second half of the 1980s, placing drinking water sources as well as the energy reserves for major cities like La Paz and El Alto at risk (Morales 2010). At the same time, desertification is progressing rapidly in the Altiplano, the inter-Andean valleys, and the Chaco, which are home to the bulk of Bolivia's population. Desertification now affects 41 percent of the national territory (Mariscal 2011), with aridity indices[52] projected to decrease by up to 20 percent in a 2°C world and up to 40 percent in a 4°C world (World Bank 2014). In the Amazon Region, increased climate variability is inducing a higher incidence of drought as well as more frequent and intense flooding during the rainy season, leading to significant water stress: by 2050, the estimated cost of the additional water storage required to meet the monthly need for irrigation water as a result of climate change will range from US$12 million to US$60 million (World Bank 2010).

Figure 36. Projected climate change impacts on rainfall and temperature, Bolivia, 2040–69

a) Rainfall b) Temperature



Source: Built with World Bank Spatial Agent, using data from Climate Wizard

Note: Projections under A2 Scenario, 60% ensemble model, annual season.

52 The Aridity Index (AI) is an indicator designed for identifying structurally arid regions, i.e. regions with a long-term average precipitation deficit. Lower AIs indicate higher levels of aridity, with hyper-arid areas, generally coinciding with the great deserts, typically displaying AI values between 0 and 0.05 (World Bank, 2014).

Climate change scenarios reveal patterns that further affect drought and flood risks in food systems across Bolivia. An increase in the variability of rainfall and in the occurrence of periodic droughts could have important implications for quinoa, maize, soybean, and potato production systems. Under a dry scenario, crop yields are expected to decline (up to 40 percent for maize and soybean), mostly due to water shortages and hot spells during critical crop stages.[53] A climate change impact risk analysis was conducted to identify priority food systems for government action in the face of climate change.[54] Any disruption, not only in food production but also in food processing, marketing, and consumption, will affect food security outcomes in the most vulnerable areas, both rural and urban. Food commodities that are highly exposed and sensitive to floods and/or droughts include cereals (maize, rice, wheat, and quinoa); industrial commodities (soybeans, sunflower seed, and sugarcane); tubers (potatoes and cassava); meat, milk, and eggs (cattle, llamas, and chickens); vegetables (peanuts, green beans, green peas, beans, onions, and carrots); and fruits (bananas and plantains). All of these commodities (fresh and processed) are highly relevant for food security, as part of the Bolivian food basket.

Table 21 presents a summary of relevant hazards for food commodities by region and department. The National Strategy for Agriculture Risk Management and Climate Change Adaptation (MDRyT 2018) proposes three macro-regions, according to their level of risk: Region I (R I) – Altiplano and Valles, Region II (R II) – Amazonía and Llanos Tropicales; and, Region III (R III) – Chaco. Regions I and III are more exposed and sensitive to drought, while Region II is more exposed and sensitive to floods.

53 World Bank 2010.

54 Developed on the basis of secondary data: national census and surveys from National Statistical Institute (INE), The Agro-environmental and Productive Observatory from Ministry of Rural Development and Land (MDRyT), The Agricultural Risk and Climate Change Atlas for Food Sovereignty (MDRyT, 2014), and the National Strategy for Agricultural Risk Management and Adaptation to Climate Change (MDRyT, 2018).

Table 21. Major hazards for food commodities by region and department

Region	Major Hazard	Food Commodities - Crops	Departments
RI	Drought	Quinoa (67,000 ha), Potato (50,500 ha), Wheat (14,000 ha), Green Beans (9,000 ha), Green Peas (9,000 ha), Banana (4,000 ha), Onion (3,800 ha), Carrots (3,200 ha), Plantain (3,000 ha) and Beans (2,000 ha)	Chuquisaca, Cochabamba, La Paz, Oruro, Potosi, Santa Cruz and Tarija
RII	Floods	Soy (1,475,000 ha), Sunflower (164,200 ha), Rice (150,000 ha), Corn (130,000 ha), Sugar Cane (124,000 ha), Wheat (92,000 ha), Beans (47,900 ha), Cassava (15,300 ha), Plantain (13,700 ha), Banana (11,400 ha) and Peanuts (3,600 ha)	Beni, Cochabamba y Santa Cruz
RIII	Drought	Corn (80,000 ha), Peanuts (9,400 ha) and Beans (6,500 ha)	Chuquisaca, Santa Cruz and Tarija
Region	**Major Hazard**	**Food Commodities - Livestock**	**Departments**
RI	Drought	Poultry (215,000 chickens) and Llama (1,280,000 heads)	Chuquisaca, Cochabamba, La Paz, Oruro, Potosi and Tarija
RII	Floods	Poultry (176,000 chickens) and Cattle - beef and milk (3,359,000 heads)	Beni and Santa Cruz
RIII	Drought	Poultry (211,000 chickens) and Cattle - beef and milk (373,000 heads)	Santa Cruz and Tarija

Source: World Bank/FAO 2019 (unpublished background report on Agriculture and Climate Change in Bolivia)

The effects of unpredictable rainfall patterns on agriculture are often severe, such as the effects of erratic rainfall during the 1997/98 El Niño. This event led to damages in maize and soybeans valued at around US$641 million. Similarly, the total economic impact of the El Niño/La Niña weather pattern in 2007/08 was estimated at US$443 million—equivalent to 62 percent of total economic losses or 4 percent of 2007 GDP.[55] Likewise, La Niña 2017/18[56] affected approximately 2.25 million hectares, many of which were planted with summer crops

If agricultural growth in Bolivia is to deliver sustained gains for producers, value chain actors, and consumers, agricultural production systems will have to become more resilient. To understand the long-term economic impacts of climate hazards in Bolivia, a production risk assessment was carried out across 9 departments for 14 crops for which 2017 wholesale prices were available, as well as crop yield data for 1994–2017. The analysis aimed to: (1) provide indicative figures of gross production concentration values, (2) survey historical in-country losses, including losses recorded for selected crops, and (3) assess the exceedance probability of occurrence of losses. The results are discussed in the following section.

7.1.1. Estimating losses from climate-related production risks

The analysis of climate-related production risk shows that the exposure of selected crops, measured in terms of GPV, was equivalent to US$7.05 billion over 3.05 million hectares. Santa Cruz, Cochabamba, and

55 See https://www.gfdrr.org/bolivia

56 Presentation: Afectaciones Fenómeno Niña 2017-2018. Período: Dic. 17 – May18 (2018) Accessed: November 2018. MDRyT.

Table 22. Gross Production Value (GPV) per department for selected crops in Bolivia (in million US$). Period 1994-2017

Crops	Beni	Chuquisaca	Cochabamba	La Paz	Oruro	Pando	Potosi	Santa Cruz	Tarija	**Grand Total**	Pecentage distribution
Rice	53.99	0.35	8.10	11.28	-	2.83	-	285.16	0.60	**362.30**	5%
Banana	2.94	-	109.72	35.56	-	0.53	-	2.33	0.17	**151.26**	2%
Sugar cane	11.15	2.36	1.59	-	-	0.80	-	1,863.41	115.84	**1,995.16**	28%
Berley	-	3.55	1.72	8.45	2.65	-	7.02	0.04	0.30	**23.73**	0%
Bean	0.57	5.46	3.89	0.59	-	0.29	0.0	108.61	0.68	**120.11**	2%
Maize/ Corn	1.68	9.37	7.47	2.14	0.01	0.57	2.38	59.95	14.44	**98.00**	1%
Mandarin	0.96	0.25	33.24	19.42	-	0.13	-	73.23	1.89	**129.12**	2%
Potatoes	-	62.48	162.72	183.86	41.05	-	74.07	32.96	29.16	**586.31**	8%
Pineapple	4.09	0.17	157.35	4.21	-	1.90	-	3.71	-	**171.43**	2%
Plantain	98.78	0.42	490.53	175.14	-	52.51	-	78.99	0.03	**896.41**	13%
Quinoa	-	0.12	0.66	15.45	61.34	-	43.33	-	0.01	**120.91**	2%
Sorghum	-	-	-	-	-	-	-	208.91	1.33	**210.24**	3%
Soybean	-	0.12	-	-	-	-	-	2,008.59	14.80	**2,023.51**	29%
Wheat	-	7.98	11.90	0.86	0.38	-	9.25	131.58	0.62	**162.57**	2%
Grand Total	**174.17**	**92.64**	**988.88**	**456.95**	**105.43**	**59.56**	**136.08**	**4,857.48**	**179.86**	**7,051.05**	
Pecentage distribution	2%	1%	14%	6%	1%	1%	2%	69%	3%		

Source: Authors' estimates based on the Observatorio Agroalimentario y Productivo.

La Paz Departments had the largest share of GPV exposed to production risk—around 89 percent. In other words, the whole agricultural sector is likely to be severely impacted if any of these departments is hit by a disaster.

Over the period from 1995 to 2017, total losses due to production risks in Bolivia are estimated at US$6.4 billion. Soybeans and sugarcane accounted for 66 percent of all losses (around US$4.2 billion in total). The average annual loss across all crops and departments under analysis is US$277.3 million (3.93 percent of total GPV). In terms of loss frequency, both wheat and sorghum experienced losses in yield once in every two years. Yield losses occurred twice in every ten years in soybeans and three times in every ten years in sugarcane.

As the data for the study period indicate, in a year when an extreme weather event occurs, crop yield losses can be almost three times as high as the average annual loss. In 1999, for instance, crop yield losses amounted to US$879.7 million across all crops and departments, but three crops accounted for 84 percent of total loss (Figure 37). Extreme crop yield losses also elevated losses in 2010 (US$594.0 million) and 2007 (US$529.5 million).

Although the historical burn analysis can give a useful indication of possible losses generated by past events, it may not be adequate to identify extreme losses which are likely to occur. To obtain more accurate estimates (or forecasts) of expected crop yield losses in Bolivia, a Monte Carlo simulation was run on 10,000 crop yield scenarios for each crop and department. This analysis shows that the average loss

Table 23. Annual Average Losses (AAL) and loss frequency per crop (1995-2017).

Crops	AAL (US$ Million)	AAL (%)	Loss Frequency (%)
Rice	15.46	4.27	36.36
Banana	1.54	1.02	33.33
Sugar cane	74.56	3.74	31.82
Barley	0.96	4.05	29.87
Bean/Poroto	1.72	1.43	38.64
Maize/Corn	3.32	3.39	27.27
Mandarin	2.52	1.95	36.36
Potatoes	8.01	1.37	38.96
Pineapple	1.68	0.98	43.94
Plantain	24.94	2.78	41.56
Quinoa	4.14	3.43	40.91
Sorghum	14.74	7.01	50.00
Soybeans	109.01	5.39	21.21
Wheat	14.65	9.01	54.55
		0.00	0.00
Total	277.26	3.93	38.21

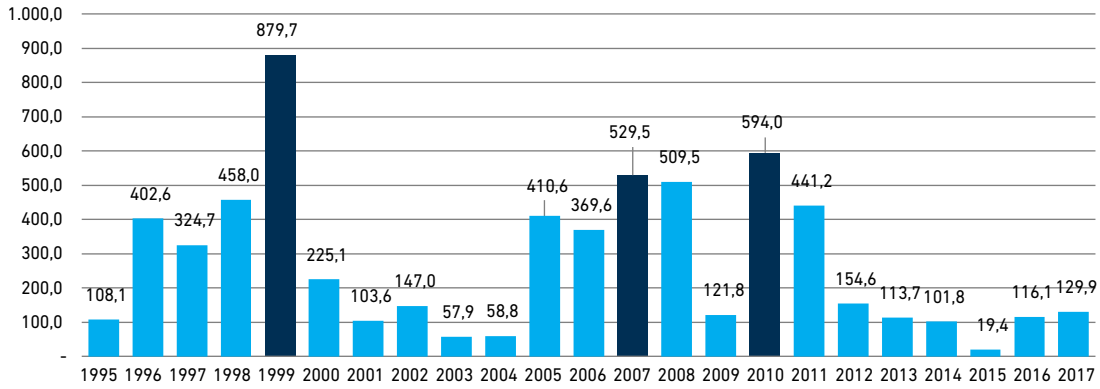
Source: Estimates based on the Observatorio Agroalimentario y Productivo

(US$285.6 million) is slightly above the value obtained from historical values (US$277.3 million), clearly reflecting a more accurate distribution of losses than can be obtained through simple consideration of the 24 historical loss values available for each crop and department. In this respect and when considering the maximum amount expected to be lost over 1-in-100 year return period (or Value at Risk—VaR—with an exceedance probability of 1 percent), the simulated data exhibit a loss of around US$892.9 million (or 12.7 percent of the total value exposed). Agricultural risk management strategies must be designed based on the likelihood and severity of losses being realized.

The average loss calculated from simulated crop yields shows that the departments in Bolivia with the highest risk levels are Santa Cruz, followed by Cochabamba and Tarija. In contrast, the departments of Pando and Oruro feature the lowest hazard levels. The production risk assessment also shows that wheat, sorghum and soybeans are the top three crops with the highest loss risks, as their weighted average losses accounted for 9.35 percent, 7.46 percent, and 5.61 percent, respectively. Due to the size of the GVP, however, the largest losses per crop are clearly concentrated in soybeans (US$113.4 million), sugarcane (US$74.2 million), and plantains (US$24.8 million).

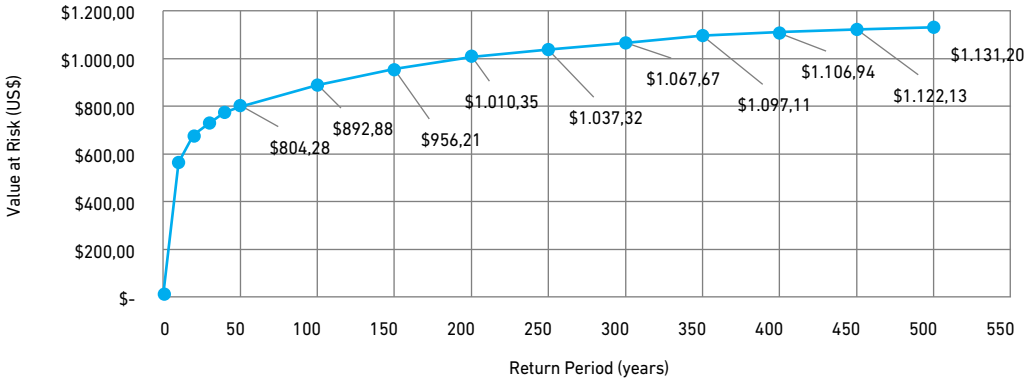
In soybeans, the VaR with an exceedance probability of 1 percent is above one-quarter (US$520.1 million) of its GPV (or US$2.02 billion). At the department level, the same VaR extends from a minimum of 7 percent in Chuquisaca to a maximum of 26 percent in Santa Cruz. In contrast, the same VaR in quinoa exhibits a weighted average loss equivalent to 13 percent (or US$15.6 million) of its GPV (or US$120.8 million). The departments with the lowest and highest

Figure 37. Historical crop yield losses of selected crops in Bolivia (US$ million) (1995-2017)



Source: Estimates based on the Observatorio Agroalimentario y Productivo

Figure 38. Value at Risk (VaR) with different exceedance probabilities in all crops and departments studied.



VaR 1-in-100 year return period are Chuquisaca (6.8 percent of its GPV) and Oruro (21 percent of its GVP).

7.1.2. Government efforts to manage production risks

In response to the exposure of the agricultural sector to climate-related risks, the Bolivian government has supported a series of policy interventions. A prominent intervention has been the effort to develop an agricultural insurance market. In 2011, the National Agricultural Insurance Institute (INSA, its Spanish acronym) was established, with a mandate to operate and regulate the national agricultural insurance program (also known as "Pachamama") and the insurance premium subsidy program allocated annually for different insurance schemes (Box 5).

Table 24. Simulated weighted average loss cost per crop and per department.

Department/ Crops	Rice	Banana	Sugar Cane	Barley	Bean	Maize	Mandarin	Potatoe	Pineapple	Plantain	Quinoa	Sorghum	Soybean	Wheat	GPV (US$ Million)	W Avg Loss (US$ Million)
Beni	1.8%	5.3%	2.0%		5.6%	6.6%	2.8%		6.2%	6.2%					174.06	7.89
Chuquisaca	1.1%		1.9%	0.8%	1.0%	1.2%	1.1%	1.4%	0.5%	1.3%	0.9%		0.9%	5.9%	92.58	1.63
Cochabamba	1.0%	1.2%	2.5%	2.7%	1.1%	1.1%	1.2%	1.7%	0.8%	2.4%	2.3%			4.9%	988.26	18.35
La Paz	0.5%	0.5%		6.7%	1.7%	3.9%	7.6%	0.8%	2.3%	2.0%	2.8%			5.2%	456.66	7.85
Oruro				9.9%		7.9%		1.8%			3.3%			7.6%	105.36	3.09
Pando	3.3%	4.5%	5.7%		9.9%	3.6%	2.9%		8.0%	3.4%					59.53	2.15
Potosi				0.7%	3.9%	4.3%		2.2%			3.6%			4.5%	135.99	3.71
Santa Cruz	5.5%	1.0%	3.5%	0.9%	2.2%	4.8%	0.7%	1.7%	1.7%	1.9%		7.5%	5.6%	10.4%	4,854.42	231.27
Tarija	2.2%	0.7%	7.6%	1.1%	0.8%	2.3%	1.6%	1.5%		1.6%	2.3%	1.3%	0.7%	1.7%	179.75	9.70
GPV (US$ million)	362.07	151.17	1,993.90	23.71	120.04	97.94	129.04	585.94	171.32	895.84	120.83	210.11	2,022.24	162.46	7,046.61	
W Avg Loss (%)	4.65%	1.14%	3.72%	4.04%	2.16%	3.81%	1.92%	1.43%	1.03%	2.76%	3.34%	7.46%	5.61%	9.35%		
W Avg Loss (US$ Million)	16.82	1.72	74.18	0.96	2.59	3.74	2.47	8.38	1.76	24.77	4.04	15.68	113.35	15.20		285.65

Table 25. Value at Risk with an exceedance probability of 1% for different crops in Bolivia.

Department/ Crops	Rice	Banana	Sugar Cane	Barley	Bean	Corn	Mandarin	Potatoes	Pineapple	Plantain	Quinoa	Sorghum	Soybean	Wheat
Beni	13.79%	27.37%	18.16%		33.64%	39.10%	11.19%		33.12%	32.51%				
Chuquisaca	8.11%		9.95%	5.41%	7.66%	8.60%	8.23%	8.18%	3.88%	9.19%	6.76%		6.96%	15.73%
Cochabamba	7.48%	8.76%	9.78%	16.29%	11.37%	10.25%	7.28%	10.57%	5.91%	11.78%	20.79%			11.34%
La Paz	4.21%	3.44%		35.89%	7.55%	23.53%	42.68%	5.87%	20.69%	10.67%	17.82%			12.22%
Oruro				38.74%		45.95%		9.47%			20.93%			41.08%
Pando	17.84%	27.37%	31.84%		41.88%	21.39%	11.45%		41.21%	14.95%				
Potosi				5.72%	34.23%	28.15%		19.78%			16.94%			13.36%
Santa Cruz	46.88%	6.32%	28.23%	9.55%	20.32%	29.39%	5.76%	10.54%	7.64%	11.08%		36.99%	25.91%	64.90%
Tarija	16.35%	7.57%	30.45%	7.73%	7.55%	16.40%	7.42%	14.22%		10.78%	10.39%	8.50%	7.43%	11.24%
VaR 1-100 years (%)	37.51%	6.65%	26.88%	14.68%	18.57%	18.77%	7.88%	4.69%	5.82%	8.71%	12.88%	36.76%	25.72%	53.54%

Box 5. Agricultural insurance in Bolivia

SAMEP insurance program was designed by INSA in the form of a compensation payout mechanism (also known as PIRWA) to protect small-scale farmers who had historically been excluded from commercial agricultural insurance. Since 2012/13 when the SAMEP instrument became available, the cultivated area protected through this coverage increased from 91,226 hectares to 315,693 hectares. In the five years from 2013/14 to 2017/18, compensation payouts amounted to approximately Bs 88.8 million, covering 113,866 small-scale farmers. Because of El Niño, the 2016/17 crop season had both the largest area affected (exceeding 139,000 hectares) and the highest number of enrolled farmers who received payouts (more than 43,500 farmers).

Table 26. Evolution of SAMEP program (2013-2017)

Year	N° Municipalities	N° Communities	N° Farmers (covered)	Covered Area (ha)	Affected Area (ha)	Compensation payouts (Bs.)	Compensated farmers
2013	63	2,491	57,497	91,226	8,469	7,601,460	7,141
2014	107	4,631	106,049	175,892	19,910	18,061,748	23,425
2015	141	5,575	146,563	272,886	6,866	6,463,856	11,148
2016	142	5,379	135,456	249,893	33,992	32,111,987	43,536
2017	140	6,186	168,705	315,693	25,338	24,560,182	28,616
Total	**593**	**24,262**	**614,270**	**1,105,590**	**94,575**	**88,799,233**	**113,866**
Avg	**119**	**4,852**	**122,854**	**221,118**	**18,915**	**17,759,847**	**22,773**

Source: INSA (Seguro Agrario en Bolivia. Modalidad Catastrófica "PIRWA")

Compared to other programs developed in the region, the Bolivian program pays the highest indemnity value per hectare. This SAMEP compensation payout was established with the objective of covering farmers´ food expenses if insured crops suffered severe losses owing to extreme weather such as a drought, flood, frost, or hailstorm. Enrolled farmers are entitled to received Bs 1,000 per hectare (approximately US$147.05 per hectare) for up to three hectares. In comparison, Mexico's program for responding to natural disasters (CADENA) has an insurance mechanism that protects the federal and state governments from the financial losses incurred in aiding farmers who grow rainfed crops and have no access to commercial insurance. When an insured event occurs, the policyholder (the federal and state governments) distributes a pre-agreed lump sum per hectare (Mx$1,500 or US$75 per hectare) of rainfed crop. In northeastern Brazil, the popular Garantia Safra program disburses R$850 (equivalent to US$216.87)[57] divided into five installments to farmers whose monthly family income is less than 1.5 times the minimum wage and who crop 0.6–5 hectares. The Garantia Safra compensation is triggered when the yield of target crops at the municipality level is 50 percent or less than the expected yield.

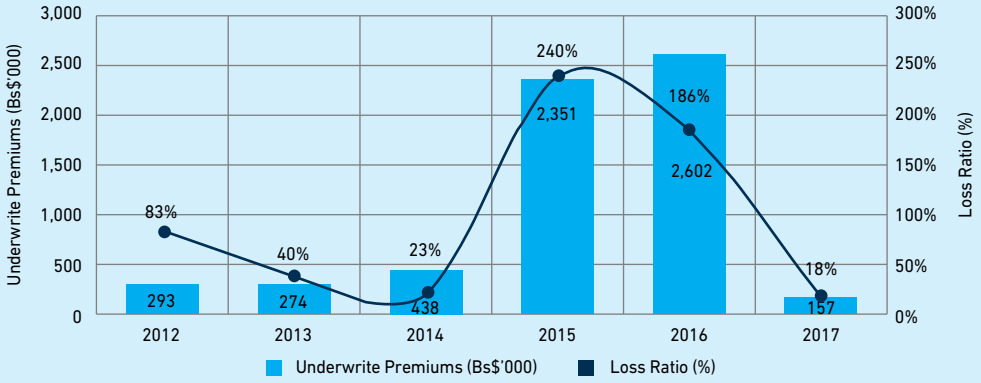
57 Exchange rate of R$3.92 per US$1 on December 12, 2018.

Community leaders and community organizations play an essential role in running SAMEP. The 60 INSA technicians cannot meet the needs of the 122,800 farmers who benefit annually from the program, so work contributed by representatives of municipal administrations and community leaders is critical for supporting INSA technical staff in enrolling producers and assessing field losses. A training program to enhance efficiency, improve skills, and standardize SAMEP´s operating procedures would help to reduce errors that could affect the frequency of payments (for instance, repeated payouts to farmers who grow the same crop within the same geographical region owing to human misjudgment or—in extreme cases—moral hazard).

Currently, the Government of Bolivia absorbs all costs involved in assisting small-scale farmers who experience extreme agricultural losses. Unlike Mexico's CADENA program, in which the government is insured against any losses resulting from this kind of assistance, SAMEP´s operational costs and financial losses are not transferred to a third party. For that reason, INSA has limited budgetary scope to roll out operations to new geographical regions and benefit larger numbers of farmers. The current legal insurance framework contains provisions for subsidizing crop insurance premiums as an incentive for the insurance sector to do business and provide coverage to small-scale farmers. Information on the financial resources available for these subsidized premiums and the procedures to be followed by the insurance industry is not clear, however. For that reason, the insurance industry continues to offer crop insurance products only for a subset of clients and regions, for whom the operational costs of indemnity-based products are manageable.

Development of an agricultural insurance market that enables commercial farmers to transfer risk to a third party is still at an embryonic stage. In 2017, direct written premiums for agricultural insurance amounted to Bs 157,000 (US$23,088) handled by three companies, La Boliviana Ciacruz de Seguros y Reaseguros (Bs 44,000), Seguros y Reaseguros Credinform International S.A. (Bs 46,000) and Alianza Compañía de Seguros y Reaseguros S.A. E.M.A. (Bs 67,000). Given the low penetration agricultural insurance products, farmers have limited knowledge of their existence and how they work, and it is likely that only farmers who operations are exposed to serious risks are willing to pay for insurance coverage—creating the problem known in the industry as adverse selection.

Figure 39. Agricultural underwrite premiums and loss ratio (2012-2017)



Source: Insurance and Occupational Pension Authority (APS)

Source: Authors

Agricultural insurance is one of the most complex types of business. Substantial resources are needed to convene a multidisciplinary group of experts (agro-meteorologists, agronomists, legal experts, agricultural economists, and others) to assess whether any type(s) of agricultural insurance instrument(s) might offer viable solutions for different stakeholders. Given public budget restrictions and the inconsequential volume of premiums, the design of new insurance products depends largely on support from donors. In recent years, Swiss Cooperation—through PROFIN Foundation—has made funds available to implement insurance products, but they never reached sustainable commercial levels after the subsidy of insurance premiums ended.

Another role of agricultural insurance can be to minimize default risk for credits approved by financial institutions for agricultural investments. The Government of Bolivia enacted the Financial Services Act N° 393 as part of its objectives to increase economic growth of productive sectors, rural areas, and low-income populations, but some provisions of this law have restricted the development of synergies between the agricultural insurance and financial industries. The act mandates all financial institutions to allocate a minimum percentage of their portfolio to productive sectors (Art. 66), and it limits the fees and interest rates that can be charged to clients (Art. 59). These provisions have had the unwelcome spillover effect of undermining the efforts of medium and small insurance companies to work with financial institutions to insure agricultural loans, because the Financial Services Act essentially forces financial institutions to focus on providing services to the clients who generate the lowest costs of banking. For that reason, credit for productive sectors is concentrated among fewer clients, which raises the overall risk of credit default and the risk that a borrower´s creditworthiness will decline.[58]

The oversupply of financial services to selected clients, combined with the lack of an insurance culture, makes it less likely that the agricultural insurance

58 Although the default rate on the credit portfolio for productive sectors in 2017 was slightly lower than in 2016, it surpassed 30 percent of the total default rate portfolio.

market will advance. Farmers do not perceive the tangible benefits of risk transfer products unless disaster strikes, so they regard insurance as an additional cost that could be eliminated. Financial institutions can be reluctant to promote agricultural insurance products because they fear losing clients if they require them to purchase agricultural insurance as a prerequisite for the approval of a loan, or if they require grant funding for the purchase of insurance products.

The Government of Bolivia has also promoted the development of information systems to help decision makers monitor hazards and provide farmers affected by weather or climate-related hazards with an early response. Since 2017, the Rural Contingency Unit of MDRyT has integrated state-of-the-art geographic information technology, meteorological data, and forecasts with ancestral traditional knowledge into an Early Warning System for the Agricultural Sector (SAT).[59] This information platform monitors the evolution of weather hazards and provides information that the authorities use to take action to reduce or alleviate sector-wide impacts. SAT weather forecasts are generated in close collaboration with the National Meteorology and Hydrology Service of Bolivia (SENAMHI). SAT also allows end-users to compare SAT outputs with biotic weather forecasting indicators and informs farmers about seeding dates that are the least exposed to agro-meteorological risks.

7.1.3. Suggestions for reducing production risks

The production risk analysis described in this chapter for selected crops across all departments in Bolivia shows that severe losses are likely to occur as a result of climate variability and climate change. At the same time, the vulnerability of the agricultural sector can be reduced by strengthening and/or reforming some of the agriculture risk management initiatives currently implemented by the government.

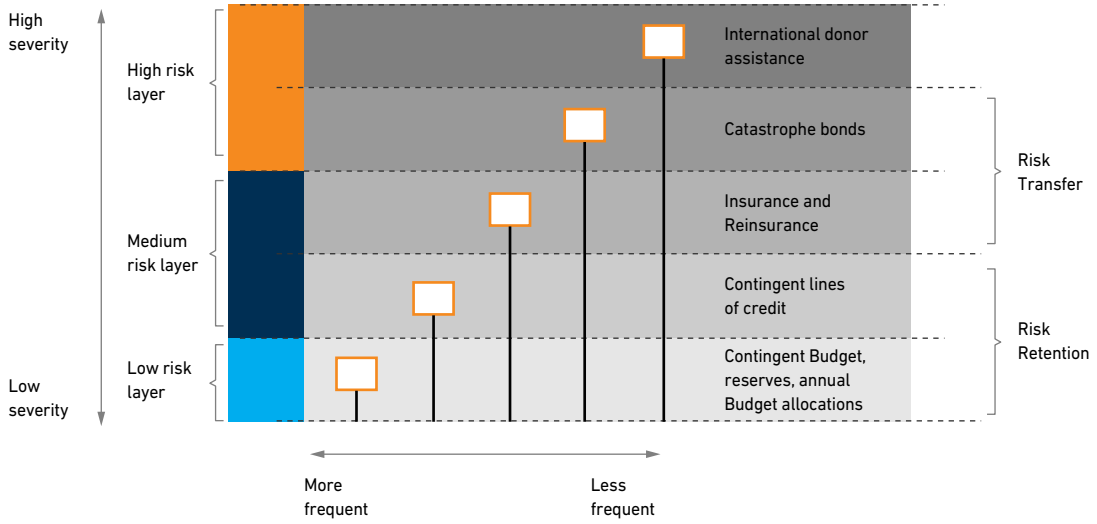
Continued strengthening of INIAF and the agricultural innovation system (SNIAF) more broadly is critical for effective agricultural risk management. INIAF, as the coordinating entity of SNIAF, can contribute to risk reduction through the development, validation, and promotion of improved technologies (high-yielding crop varieties that can withstand climate stress, improved silage systems); the provision of advisory services; the production and availability of certified seed, and enhanced collaboration among innovation agencies.

Today, government actions focus on generating information (SAT) and implementing a compensation mechanism (PIRWA) for subsistence farmers. Such initiatives are important and valuable and need sustained financial support. Yet it is important for them to form part of an integrated risk management agenda that increases producers' awareness of the potential impacts of risks and helps them to adopt strategies for adaptation, risk transfer, and coping (tailored to the needs of subsistence and commercial farmers) to reduce those impacts and protect the long-term sustainability of their investments.

The agricultural insurance market is not likely to expand rapidly under the current legal framework for financial services. Nevertheless, other financial instruments and budgeting mechanisms could be combined to address the government´s need to fund compensation for farmers following a disaster (Figure 40). The government should develop a risk financing mechanism that is based on the probability of occurrence and the severity of hazards in the agricultural sector and that maintains adequate and cost-effective sources of financing (ex-ante instruments and ex-post measures) to smooth the cost of risks and minimize fluctuations in costs. The PIRWA program is currently the vehicle established by INSA to compensate smallholders for losses caused by adverse weather, and the government has no other risk retention or risk transfer tool to boost its financial

59 http://sat.agro.bo

Figure 40. Risk layering and implementation of suitable financial instruments



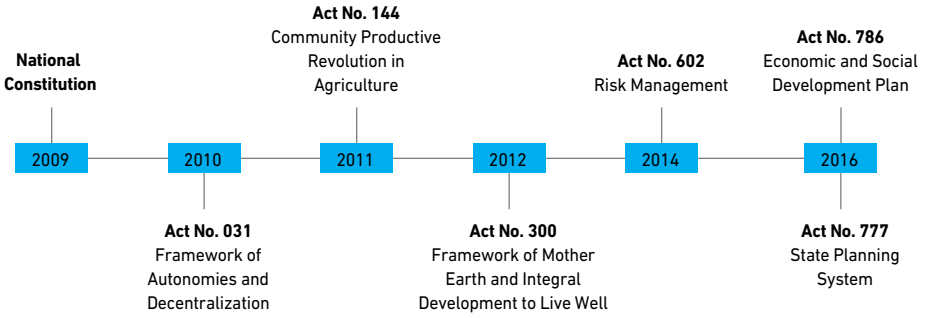
Source: Adapted from Clarke and Mahul, 2011

response to losses in the agricultural sector. Figure 40 shows a hypothetical example of a risk financing structure based on the concept of risk layering.

The SAT early warning system should meet the needs of stakeholders outside the MDRyT system. A great effort has been made to identify the thresholds for crop damage and yield loss, but the data and information currently available are insufficient to characterize weather hazards and assess loss estimates that have a specified probability of exceedance of risk at the local level. For that reason, at present the SAT cannot be used for formulating and implementing risk preparedness and mitigation plans. To harness SAT´s potential, the following inter-related actions are required:

- **Increase the accuracy of hazard monitoring and forecasting to establish effective risk management interventions.** At present, MDRyT works in collaboration with SENAMHI to generate meteorological and hydrological bulletins at both the regional and department levels. For this purpose, the SAT should integrate new sources of time-series data with sufficient intervals and completeness. Decision-makers in Bolivia should consider the scope for integrating private weather station networks into the national network and making use of remote sensing technology for early drought detection, monitoring, and impact assessment. The SAT should improve not only the spatial resolution of the information shown in the bulletins, but also work on the generation of agro-meteorological indexes that are simpler and user-friendly (such as crop water requirement indexes and vegetative stress indexes).
- **Improve the communication and dissemination of information (monitoring information as well as warnings) on agrometeorological hazards.** This information should reach the people who are exposed to hazards, and it should be adapted to their level of understanding so that they can act on it. Currently MDRyT disseminates SAT-related data

Figure 41. Bolivian legal framework on agricultural risk management



through the internet and field extension officers. Decision-makers should explore the dissemination of early warnings through other channels—mobile phone, SMS messaging, television, radio—that are far more likely to reach stakeholders in a timely way and give them more lead time to take action.

- **Develop a clear process to alert decision-makers at all levels about impending hazards so that they can coordinate a response based on previously developed contingency plans.** The government has systems in place to identify disasters in the making, but it lacks a clear process for decision-makers at more local levels to act on that information as quickly as possible. The operation of SAT and implementation of any other risk management activity are enshrined in a legal framework that is intended to reduce the probability that hazards will become full-blown disasters. In practice, however, SAT contributes information to the National Risk Management System (SISRADE), and that system is used to coordinate rehabilitation, recovery, and reconstruction interventions across institutions (in other words, it comes into play after a disaster has occurred). The true challenge is to implement a clear process for decision-making at the subnational level for reducing farmers' vulnerability to impending external shocks such as agrometeorological risks. The MDRyT should define a methodology that local experts can use to assess losses and damage at the subsector level, develop and strengthen the technical capacity of community leaders and members of community organizations to use it, draft contingency plans that trigger activities based on reliable information about potential disasters, and integrate those measures in development plans to accelerate the response. The SAT should contain a risk module that allows users to estimate the magnitude and associated annual probability of hazard (a hazard component), appraise the asset at risk (exposure component), and identify the damage against the asset at risk, given the magnitude of the hazard (vulnerability component).

A risk module cannot be implemented for all hazards that are relevant for agriculture, but Bolivia can certainly draw upon the vast international experience with drought monitoring systems. For instance, the Ministry of Agriculture and Livestock (MAG) of Paraguay developed a Crop Water Balance Model (BHAg) to monitor crop yield reductions due to severe drought and estimate the impact on crop output. The BHAg also helps to monitor the occurrence of extreme rainfall events during the most critical stages of crop growth. Similarly, the Office of Agricultural Risk (ORA) in Argentina estimates the probability that water deficits and excess rainfall will occur in selected crops and pasture. Such information is used by the Agri-

cultural Emergency Unit of the Ministry of Agriculture to identify affected areas that are likely to call for a state of emergency or declaration of disaster, and for which the federal government will have to allocate resources to compensate affected farmers. Finally, under the Garantia Safra program, the Ministry of Agricultural Development (MDA) of Brazil uses a crop water balance model to estimate crop losses due to severe drought and determine whether participating farmers should receive a payout.

In alignment with risk management options to mitigate and transfer risks, an integrated framework to risk management will imply also measures to cope and adapt to risks. For this, irrigation will continue to be critical, particularly in regions where water scarcity is a concern, as well as the adoption of a range of climate-smart practices for specific crops and regions.

7.2. Reducing the environmental footprint of agriculture

While a major challenge for the agricultural sector is to reduce its vulnerability to climate change, a major opportunity is to reduce its environmental footprint. Agriculture worldwide contributes approximately one-third of GHG emissions. In Bolivia, the sector is a major contributor. Many farming practices—such as burning fields and using gasoline-powered machinery, cattle ranching, and the use of chemicals—add significantly to the buildup of GHGs in the atmosphere.[60] According to Friends of Nature Bolivia, 77 percent of Bolivia's emissions come from the conversion of forest into agricultural land.[61] Destruction of tropical forests and other native vegetation for agricultural production has a role in elevated levels of CO_2 and other greenhouse gases.

Bolivia has serious land-use challenges, including the unsustainable conversion of land to agricultural uses, soil degradation, and conflict over land. Of Bolivia's 109 million hectares, 57 million hectares are forest,[62] covering 50.6 percent of the territory. From 2001 to 2011, about 2 million hectares were deforested in Bolivia,[63] with an annual median of 181,864 hectares per year. From 2012 to 2017 deforestation increased by 1.3 million hectares, with an annual median of 219,501 hectares per year. By 2017, total deforestation in Bolivia had reached 7 million hectares (including the cumulative deforestation to the year 2000, which was estimated at 3.6 million hectares). This area corresponds to 12.3 percent of Bolivia's total forested area and 6 percent of its national territory.

Rapid expansion of agriculture, and particularly livestock production, has driven a large proportion of this deforestation (Table 27). Santa Cruz Department accounts for 64 percent of all tree cover lost nationally between 2001 and 2017. The department has lost 9.6 percent of its tree cover, followed by Cochabamba (7.6 percent) and Beni (6.1 percent).[64]

Concerns about further deforestation have emerged in light of the recent policy around biodiesel use. The government has ambitious goals for expanding biofuel (ethanol) production to substitute for gasoline imports and reduce GHG emissions. In 2018, it passed a mandate to begin producing ethanol from sugar-

60 WWF 2018 Greenhouse gases, such as carbon dioxide, trap heat in the atmosphere and regulate our climate. These gases exist naturally but humans add more carbon dioxide by burning fossil fuels for energy (coal, oil, and natural gas) and by clearing forest.

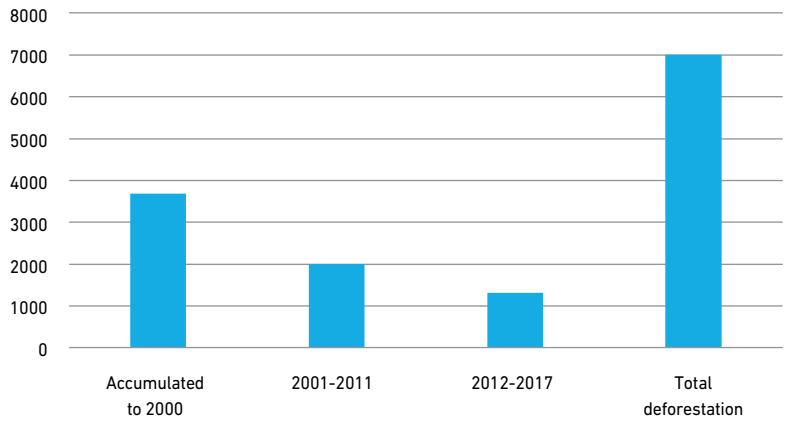
61 Fundacion Tierra 2019, Conferencia sobre la Agenda Abandonada de la Madre Tierra

62 Wanderley Ferreira, 2018 Estado de la situación de la deforestación en Bolivia. Conference on Mother Earth.

63 Deforestación en el estado plurinacional de Bolivia Periodo 2016-2017. Ministry of Environment and Water (MMAyA, Spanish acronym), 2018.

64 Global Forest Watch, 2018 www.globalforestwatch.org/dashboards/country/BOL

Figure 42 . Deforestation in Bolivia



Source: Ministry of Environment and Water, 2018

Table 27. Dominant drivers of tree cover loss by 2015

Driver [a]	Area (kha)	Area (%)
Commodity driven	125,0	75,8
Shifting agriculture	37,8	27,9
Forestry	1,3	0,8
Wildfire	0,75	0,4

Source: Global Forest Watch

a "Commodity-driven deforestation" is the long-term, permanent conversion of forest and shrubland to a non-forest land use such as agriculture, mining, or energy infrastructure. "Shifting agriculture" is defined the conversion of small to medium-scale forest and shrubland for agriculture that is later abandoned and followed by subsequent forest regrowth. "Forestry" is large-scale forestry operations occurring within managed forest and tree plantations. "Wildfire" is large-scale forest loss resulting from the burning of forest vegetation with no visible human conversion or agricultural activity afterward.

cane and sorghum, and in 2019 it approved the use of genetically modified soybean varieties to produce biodiesel, which is expected to bring an additional 150,000 hectares under sugarcane production and about 250,000 hectares under soybeans. The government plans, expressed in PDES, is to expand agricultural production on an additional 1.2 million hectares. This expansion could have devastating impacts on the environment and Bolivia's key ecosystems if not properly guided and monitored.

The impacts of biofuels on the environment and food security are still being monitored in developed countries. FAO has reported that the impact of biofuels on GHG reduction is not necessarily positive, given that in most cases new land is brought into production (for

instance, through deforestation) to produce the crops that will meet the growing demand for biofuels.[65]

Policies around land use management are critical to ensure a more environmentally sustainable agricultural expansion. Current regulatory framework for agricultural land use in Bolivia is governed by PLUS (a land management plan), which in the case of Santa Cruz, was approved in 2003 (Ley el Decreto Supremo 24124) as its instrument for land use management (*ordenamiento territorial*). In the case of Santa Cruz, PLUS is based on maps developed in 2009 at a scale of 1:250,000. Under the PLUS framework, farm management plans (Plan de Ordenamiento Predial, POP) determine the feasibility of using land for a specific agricultural purpose and evaluate whether the soil is suitable for agriculture or whether forest is to be cleared. A recent regulation (September 2015) allows up to 20 hectares of forest to be cleared for agriculture or livestock production on small properties and on community or collective land (in which case the law permits clearing up to 20 hectares of forest per family unit). The regulation does not require a POP or plan for integrated land and forest management to be presented to the authorities before clearing land.

Bolivia has significant opportunities to improve land use planning and management, and it can benefit from regional lessons and experience with many models. One example is the effort by the Agricultural and Rural Planning Unit (UPRA) in Colombia to define the agricultural frontier based on land use in 2010 and then optimize land use (including degraded land) for agriculture, based on maps moving from a 1:100,000 scale to a more precise 1:25,000. This detailed planning processes should reduce deforestation and land use conflicts in Colombia (Box 6).

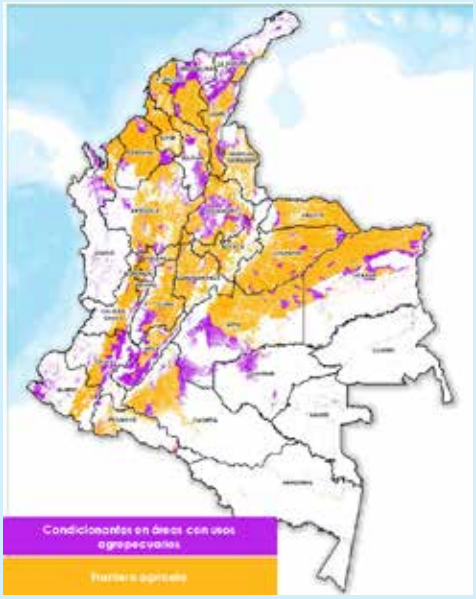
Agriculture also contributes to water pollution and soil degradation. A 2014 study in Bolivia identifies agro-chemicals as the main source of water pollution (39.1 percent), followed by industrial waste (20.9 percent) and mining (15.6 percent). Water is most contaminated by agro-chemicals in Santa Cruz (63.4 percent), Cochabamba (60.9 percent) and Tarija (56.7 percent).[66] Overuse of surface water and groundwater for irrigation without allowing for natural cycles of replenishment can become an important challenge for Bolivia. The agricultural sector uses 70 percent of all available water. Unless producers use more resource-efficient technologies and practices, agriculture consumes excessive water and energy and degrades water quality. There are important opportunities to promote and mainstream energy-efficient technologies, not only in relation to irrigation, but across a range of agriculture activities. For example, in Mexico, the Bank supported the adoption of energy efficient technologies in the livestock sector which generated emission reductions estimated at 6 million tons of $CO_{2.}$

The use of insecticides in Bolivia has almost quintupled from 10,430 tons in 2004 to 50,000 tons in 2015 as more land has come under cultivation, particularly in the lowlands. Domestic consumption of fertilizer is expected to increase importantly in the years to come (in 2015, domestic consumption of urea was estimated at 66 MT/day, 20 MT/day more than the levels achieved in 2012). Research has demonstrated that these chemicals significantly affect not just on the immediate natural resources such as soil and water, but also the biodiversity of plants and species that are beneficial to an ecosystem. Furthermore, soil degradation is a challenge in Bolivia, the MDRyT has stated that 41 percent of Bolivian territory have degraded soils. The main causes are considered to be the loss of tree cover and unsustainable practices in extensive agriculture.

65 FAO 2018, Sustainable Bioenergy.

66 National Institute of Statistics (INRA) 2014 Bolivia: causas de contaminación del agua según departamento

Box 6. Efforts to improve land use management in Colombia: Definition of the agricultural frontier as a powerful tool to guide land use planning and reach multiple goals



The **Unit for Land Use Planning** (*Unidad de Planificación de Tierras Rurales, Adecuación de Tierras y Usos Agropecuarios*, UPRA) was created by National Decree in 2011. Its main functions include the planning of rural land use and land improvement processes for agricultural purposes through the generation of technical, economic, social, and environmental criteria and guidelines, as a basis for the definition of policies aimed at the sustainable development of natural resources and economic activities. UPRA oversees the technical studies undertaken across various departments of Colombia to assess the suitability of land and inefficiencies of current land use. UPRA also undertakes studies on the functioning of regional land markets.

In 2018, UPRA, in collaboration with the Ministry of Agriculture and Rural Development and the Ministry of Environment and Sustainable Development, defined and identified the **National Agricultural Frontier.** The frontier has the dual purpose of ensuring that competitive agricultural entrepreneurship is aligned with sustainable development—in other words, to ensure that rural development is accompanied by the protection and conservation of key ecosystem services. The agricultural frontier in Colombia is defined based on rural land thresholds that separate areas where agricultural activities can be developed from areas where agriculture can be undertaken under certain conditions, areas that are protected, areas with special ecological importance, and areas where agricultural activities are excluded by law.

According to this definition, 35 percent of the continental area of Colombia represents the land area where economic activities related to agriculture, including livestock, forestry, aquaculture, and fishing, take place. This is the area that in its entirety should be the focus for developing and managing public policy

for agriculture, including the efficient use of rural agricultural land and the regulation of rural property for productive and social purposes.

From a land use planning perspective, delineation of the National Agricultural Frontier can guide the identification of areas suitable for agricultural production, reduces uncertainty for investors and entrepreneurs seeking to develop agricultural activities, and facilitates coordination of land management to promote agriculture. From a social perspective, the agricultural frontier can guide programs to provide access to land under the agrarian reform by identifying areas with a suitable agricultural profile. It also helps to stabilize the land market, guide land adjudication schemes, and support the productive occupation of rural land.

Perhaps one of the greatest innovations of this tool is that it reconciles environmental and productive goals. The definition of the agricultural frontier serves as input for the design of differentiated strategies and joint work between the environmental and agricultural sectors, fishing and rural development, for the control and containment of the agricultural frontier. It will help to stabilize and reduce the loss of environmentally important ecosystems and improve their protection, which will promote the adequate supply of ecosystem services such as water and biodiversity. In addition, it will help to reduce deforestation through strategies to contain the agricultural frontier.

Overall, the National Agricultural Frontier in Colombia is changing the image of the agricultural sector, nationally and internationally, to the extent that it sends an exemplary message of rural agricultural development occurring alongside the conservation and protection of key ecosystems for the provision of environmental services.

Source: UPRA 2018

As a definer of environmental mitigation, the government has been playing an important role through its high-level political endorsement and advocacy for climate change and green growth. Bolivia has campaigned for global sustainable practices to tackle climate change, supported climate change mitigation and adaptation agreements, and spoken openly on the responsibility of countries to assume their own climate debt. National plans propose actions for the agricultural sector to reduce GHG emissions and improve adaptation to climate change. The government's new environment-based model promotes the development of environmentally sustainable production systems and reduction of pollution in a climate change context. The PDES anticipates that by 2020, 70 percent of agroindustry and cattle ranching will implement sustainable practices and will have also enhanced their resilience to climate change. The government has committed to achieve zero illegal deforestation by 2020.

At the same time, it has also committed to triple the area under surface irrigation to over 1 million hectares by 2030, which implies that a major effort will be required to use water efficiently and ensure that this expansion does not compromise the sustainability of water resources. The government has also embarked on a strategy to supply urea produced domestically and support intensification via increased input use. Thus, ensuring that intensification is done sustain-

able, via strategies that combine efficient input use with technologies and practices that enhance soil quality and soil productivity is critical.

To forestall this outcome and achieve more environmentally favorable results, Bolivia requires a deep understanding of the related risks, opportunities, and tradeoffs; flexible policies and the resources to implement them; appropriate policy instruments to promote good practices; and proper impact monitoring, evaluation, and response. Yet in Bolivia, as in most countries, these measures are not well established, and accelerated biofuel production simply increases the risk of land-use change and the associated environmental threats.

There are important opportunities to strengthen the government's role as the definer, enabler, funder, and regulator of environmental mitigation in agricultural investments in Bolivia. Table 28 illustrates the range of instruments available to policy makers to enhance Bolivia's role in reducing the environmental footprint of the agricultural sector.

While the achievement of economic and conservation policy goals requires a major effort by the government, a successful transition toward a more environmentally sustainable agriculture in Bolivia also requires a strong commitment by the private sector. Such a commitment would extend to undertaking to apply agreed environmental and social principles, for example in commodity production sustainability certifications. It would also extend to more inclusive business models that incorporate social principles. The principles of Responsible Investments in Agriculture provide a good basis for large private investors to assess social and environmental risks and mitigation options, as well as for governments to screen agricultural investors and enhance and attract responsible investors.[67]

At least four major opportunities exist to prevent agricultural expansion from repeating the mistakes of the past. First, Bolivia can learn much from the well-documented negative effects of unsustainable agricultural development in faster-growing nations of LAC as well as from emerging approaches to manage those negative effects. Particularly relevant experiences include the use of landscape approaches to reduce deforestation in Brazil's soybean production and cattle ranching systems, as well as approaches implemented in Peru's cocoa and coffee value chains and sustainable approaches to cattle production in Colombia. Equipped with such information, Bolivia can make systemic changes to move agricultural industries onto a more sustainable path. Second, farmer organizations are already leveraging environmentally sustainable practices that serve as proof of concept to bring those practices scale. Third, Bolivian farmers' ancestral knowledge of balancing nature and agriculture should be supported and more broadly disseminated. Fourth, environmental organizations and financial institutions have progressed substantially on sustainability, becoming vast sources of knowledge and best practices from which Bolivia can certainly benefit.

67 Responsible Agricultural Investment (RAI): Knowledge into Action Notes series. https://www.worldbank.org/en/topic/agriculture/publication/responsible-agricultural-investment.

Table 28. Government roles and instruments in environmental mitigation

Role	Instrument
Definer	• High-level political endorsement and advocacy for Agriculture Green Growth. • Mechanisms for ministerial coordination across agriculture, environment, ministry of production, and related sectors. • Institutional support for multistakeholder landscape dialogue, planning, and coordination. • Designation of decision-making authority across national, state, and local government levels.
Facilitator	• Promotion of supply chain eco-standards, eco-certification, pre-competitive action. • Public procurement of sustainably sourced commodities. • Public investment in infrastructure to mitigate environmental risks. • Research and technology innovation and information systems to support adaptation (e.g., land and soil maps, climate risks maps). • Packing environmental action within large, multisectoral, sustainable growth initiatives.
Funder	• Producer subsidies to reduce costs of investments or transitioning to improved practices. • Organizational subsidies to reduce cost of collective action/investment. • Public payments to landowners/land managers for ecosystem services. • Bonds and deposit refund systems (e.g., environmental performance, land reclamation, waste delivery, and environmental accident bonds). • Preferential access to bank finance for environmentally friendly producers/processors. • Improved practices adopted in state-owned enterprises.
Regulator	• Land use regulation • Establish norms for human and ecosystem health. • Direct regulation of private land use or management practices. • Direct regulation of processing industry. • Zoning and land use planning, including generating spatial information at granular scale. • Tenure and access rules for land and resources (including concession policy, appropriation of lands under production to protect nature). • Monitoring of environmental management and ecosystem health. • Financial al market regulation • Market and trade rules. • Framework for private standards. • Regulation through creation of cap and trade/floor and trade markets (e.g., carbon offset trading, nutrition trading). • Taxation of environmentally harmful practices or products. • Liability systems. • Regulatory relief for environmentally friendly companies.
Advocate	• Raising awareness of resource managers or users. • Public media campaigns to educate citizens/consumers/buyers/investors. • Public dissemination of monitoring data and evidence • Mobilizing and supporting allies and advocates

Source: Steps Toward Green: Policy Responses to the Environmental Footprint of Commodity Agriculture in East and Southeast Asia

8.

Conclusions

Photo: Shutterstock

In the coming decades, the contributions of agriculture to the Bolivian economy will remain significant. Further growth and modernization of the food and retail sector will bring opportunities to strengthen agriculture's backward and forward linkages. Opportunities for agricultural growth will also come from the potential to orient food consumption toward healthier options such as vegetables, legumes, and fruits; consumption of these foods in Bolivia remains well below global and regional averages. Increased consumption will not only improve nutritional outcomes but help to galvanize and diversify production. Directly and indirectly, the agricultural sector will contribute to growth and diversification, provide significant employment, and serve as a major driver of poverty reduction.

Unlocking the power of agriculture and food systems to grow continuously, sustainably, inclusively, and competitively will require an approach that considers the range of opportunities and challenges throughout Bolivia's macro-regions (Box 7) and then designs a range of tailored policy instruments and investments to address them. The policy actions and corresponding investments that this report identifies as critical for ensuring a sustained trajectory of inclusive agricultural growth in Bolivia are linked to: enhancing innovation capabilities; improving connectivity, logistics, and value chain coordination; bringing financial services close to farmers; managing climate risks; and strengthening public institutions. Each is discussed in turn next.

i) Enhancing innovation capabilities

While studies consistently find that investment in agricultural R&D leads to higher productivity growth, with social returns to public R&D averaging over 40 percent, investment in agricultural R&D is stagnant or falling in regions where agricultural growth is most needed.[68] This is clearly the case in Bolivia. The country's unique agro-diversity and climatic challenges require a set of innovations that need to be very localized. Institutional reforms have focused on enhancing public sector capacities for R&D, but they have lacked adequate funding, and they have not sought to align policies over the medium and long term to crowd-in private investment, incentivize knowledge sharing, and enhance the capacities of service providers. The key elements of a successful and effective innovation system are also lacking in Bolivia: institutional autonomy, stable and diversified financing, incentive structures that reward the performance of staff and scientists, programs aligned with clients' needs through public-private partnerships, and strong international R&D linkages. The gains achieved by the government to date with multilateral and bilateral support are at risk, owing to the absence of sustainable funding and strategies to retain key scientists and staff.

Along with strengthening public R&D institutions, Bolivia has many opportunities to strengthen and crowd-in other elements of the innovation system, such as agricultural universities, think tanks, and private sector capabilities. Taking advantage of these opportunities will require integrating non-government actors and improving the knowledge, networking, and coordination skills of different agents. Important opportunities also exist to build "soft" innovation capabilities such as public-private dialog for new business models (value-chain finance, export market promotion, product differentiation, certification, and traceability) and "hard" innovation in the form of R&D. In Bolivia, the range of technological opportunities extends from opportunities that are closely linked to production, post-harvest handling, and processing to opportunities for increasing resource and input use efficiency to protect the natural capital for agriculture (land, water, and biodiversity).

Another key element of an effective innovation system is strong mechanisms to disseminate knowledge and support extension and technology transfer. In Bo-

68 Draft May 2019—Harvesting Prosperity: Technology and Productivity Growth in Agriculture (World Bank, upcoming).

Box 7. Summary of current agricultural challenges/opportunities: Perspectives from Bolivia's macro-regions

Highlands and Amazon Regions (Macro-regions). A major challenge for consolidating productivity gains in the Highlands and Amazon Regions is the increasing fragmentation of agricultural land. In the two regions, average farm size does not exceed 3 hectares, but fragmentation is the most acute in the Highlands. In the latter region, agriculture is an important economic activity for rural households but represents less than 10 percent of the value added in departments such as Oruro and Potosi. The Highlands also face challenges imposed by high poverty rates and a very fragile ecosystem. Unpredictable climate and weather patterns frustrate efforts by rural families to accumulate assets and improve their living conditions. The "Southern Highlands" experienced desertification following the unsustainable expansion of quinoa production, which left producers with highly degraded and eroded soils.

In the Amazon Region, where a large share of Bolivia's diversity is concentrated, most UPAs grow traditional products such as cassava, bananas, and maize. The region has been seeking to expand commercial agriculture (mainly sugarcane and rice). It is already the major center for the collection of Brazil nuts for export. In Pando Department, agriculture is responsible for nearly 30 percent of GDP.

A first challenge in the Highlands and Amazon Regions is to address productivity constraints. The analysis of technical efficiency shows that producers in these regions display lower average levels of meta-technical efficiency and higher heterogeneity than producers in the Sub-Andean and Lowlands Regions. Approaches that support the less-efficient UPAs in the Highlands and Amazon Regions to shift their production practices and technologies toward those of the most efficient UPAs could lead to important improvements in productivity. For some crops, such as potatoes in the Highlands, a further effort is needed to reduce technology gaps and expand the technical production frontier. Given the unique characteristics of agricultural production in the highlands, innovations will need to be highly localized.

Data limitations preclude estimates of TFP by macro-region, which would provide valuable insights into the dramatically low level of aggregate labor productivity in Bolivian agriculture. This knowledge gap is important, as this low level of labor productivity probably conceals important variations in rural livelihood strategies across Bolivia. For example, in the Highlands, farmers mainly live in nearby urban settings, and agricultural work is highly seasonal, with labor migration occurring at specific periods of the year to supplement agricultural incomes.

A second challenge in consolidating gains for farmers and other actors in the Highlands and Amazon Regions is linked to value addition and market integration. In the Highlands, for example, efforts to develop the camelid value chains have shown that without a strong market orientation and private sector involvement driving production development and quality enhancement, it will take a long time for farmers to consolidate significant gains. In the case of quinoa, the opportunity lies in the convergence of public and private efforts to agree on a sectoral strategy and move from strategy to action. The development of the native potato value chain in Peru shows the power of institutional innovations to generate value for

farmers, which Bolivia could replicate. The Amazon Region has vast opportunities for the bioeconomy and the sustainable use of biodiversity.

A third challenge relates to reducing climate vulnerability. The Highlands Region must develop a strategy to reduce climate vulnerability. Some of the options available to mitigate the effects of climate change (crop rotations, or agroforestry with native species) could also help to reverse the soil degradation resulting from the unsustainable expansion of quinoa production. In the Amazon Region, an essential strategy to limit climate vulnerability is to ensure that agricultural growth does not compromise critical environmental services and that it contributes to conservation objectives.

Sub-Andean Region (Macro-region). The crop portfolio in this region is highly diversified and agricultural land is also quite fragmented. This region has been a source of important innovations, however, particularly in the emerging grape and wine industry. An important challenge in this region, although not as imperative as in the Amazon and Highlands Regions, is to improve productivity. The SFA and MTE analyses suggest that the Sub-Andean Region should focus on technological improvements that move the production frontier toward higher levels of efficiency and productivity. Another important challenge for this region is value chain diversification and market integration, particularly around a broad range of high-value crops for domestic and export markets. Meeting this challenge will require investments to increase productivity and reduce vulnerability, including investments in irrigation. The region needs to grow sustainably, ensuring the protection of watersheds, achieving efficiencies in water and energy use and sustainable use of inputs.

Lowlands Region. In this region commercial and extensive cattle production dominate agriculture. A major challenge is to achieve higher productivity in key crops such as soybeans and other growing commercially, which remain below regional standards. The ability to raise yields through intensification is largely confined to existing technology, so it will be important to focus on technological improvements that move the production frontier toward higher levels of efficiency and productivity. There is widespread consensus in Bolivia on the adoption of genetically modified seed as a strategy for improving productivity and reducing vulnerability to drought in soybeans and other commercial crops, but other key elements associated with improved practices, particularly proper soil management, are often overlooked.

A second major challenge is to enhance key elements of the enabling environment. Those elements include common enablers such as strategic infrastructure and investments to facilitate logistics, as well as sectoral enablers related to effective trade policies and incentives, not only to attract greater private sector investment but also to ensure responsible patterns of investment (by investors large and small) aligned with a greater level of environmental accountability. A third challenge is climate resilience, particularly in highly vulnerable areas such as el Gran Chaco.

Finally, the diversity of the macro-regions, their producers, and their production systems is a challenge and an opportunity in itself. Efforts to support greater productivity and competitiveness will need to reflect that variation.

livia, the dominant focus of public programs has been to enhance farm capabilities through the provision of improved "assets" such as machinery, equipment, and irrigation. To be effective, however, those assets must be accompanied by the transfer of improved technical knowledge and efforts to build producers' human capital. Bolivia has successful experience in building farmers' capacity to manage grant funds and act collectively to procure goods and inputs; it is critical to enhance the power of those experiences through strong knowledge and information transfer. Emerging digital technologies offer great opportunities to reach farmers and improve the timeliness and quality of the information they receive.

ii) Improving connectivity, logistics, and value chain coordination

Connectivity is a critical factor driving agricultural productivity and competitiveness in landlocked Bolivia. The country has higher transaction costs than countries with maritime access, where costs of building, operating, and maintaining transport infrastructure are lower. For Bolivia, strategic investments in ports, roads, and similar infrastructure are vital to competitiveness. Those investments will have to be accompanied by reductions in other post-harvest logistics costs, particularly those linked to trade procedures, export controls, and sanitary and phytosanitary inspections and certifications.

At the grassroots level, secondary and tertiary rural roads are integral to competitiveness for producers but building and maintaining them tends to be very expensive. There is a need to ensure that scarce public resources used for this purpose are directed to areas where the potential to stimulate agricultural growth is highest. Along with roads, other off-farm market infrastructure and logistics systems are needed to match demand and supply, ensure that products meet standards for quality and safety, and reduce post-harvest losses. This enabling infrastructure is particularly critical as the country moves toward greater crop diversification involving more perishable and quality-sensitive products.

Expanding coordination vertically, along the full extent of the value chain, and horizontally, through producer associations and producer networks, remains a priority. Opportunities to reinforce coordination in value chains are linked to the adoption of strategies that support and/or enhance the role of farmers and also other value chain actors, including public-private coordinating platforms or innovation platforms that convene a broad set of institutions. Efforts to support collective action by producers would benefit from systematic knowledge sharing and initiatives that go beyond individual producer organizations to develop networks of producer organizations that can be effective at the territorial/local level.

iii) Bringing financial services close to farmers

The productivity analysis indicates that access to finance/credit will help to ensure productivity in the Lowlands and Sub-Andean Regions and could gradually improve opportunities in the Highlands and Amazon Regions. Government regulatory interventions to broaden access to finance for a larger number of farmers are partially undermining credit growth dynamics among medium and small insurance companies, however. Mechanisms that facilitate the establishment of credit histories, support the development of flexible collateral arrangements, and account for seasonality in repayment schedules, among others, can be effective ways of tailoring financial services to farmers' needs. The many programs providing direct support to producers in Bolivia represent tremendous opportunities to integrate efforts to build financial literacy and pilot financial innovations.

iv) Managing climatic risks and reducing the environmental footprint of agriculture

Bolivia should be commended for efforts to develop risk transfer mechanisms to help large numbers of farmers to manage agricultural risks (insurance schemes). There are important opportunities to make current risk management strategies more effective and to expand risk management capabilities around integrated risk management approaches. The analysis in this report finds that the agricultural insurance market will not expand rapidly under the current legal framework for financial services, but other financial instruments and budgeting mechanisms could be combined to address the government´s need for funds to compensate producers for losses triggered by different types of hazards. To this end, a risk-financing strategy in Bolivia should be structured around an understanding of the probability of occurrence and the severity of hazards, and it should combine ex-ante instruments and ex-post measures to smooth the costs of risks and minimize cost fluctuations. The Early Warning System for the Agricultural Sector (SAT) could be enhanced to improve the accuracy of hazard monitoring and forecasting, the dissemination and communication of monitoring information and warnings on agrometeorological hazards, and clear decision processes for feeding alerts into decision-making.

Along with risk-transfer mechanisms, there are opportunities to continue strengthening the capacity of INIAF and SNIAF to develop, validate, and promote technologies and practices that reduce agricultural risk. Investments in irrigation and water management will be critical for reducing vulnerability and maintaining productivity gains. Improved water-use efficiency (and energy efficiency) and watershed conservation and protection are requirements for any such investments to be sustainable in the long term.

In Bolivia, agricultural activities have threatened biodiversity and other social and economic interests by increasing water pollution, competition for water, and soil degradation, and by contributing to climate change through greenhouse gas emissions. As illustrated in this report, there are important opportunities to strengthen the government's role as a definer, enabler, funder, and regulator of environmental mitigation in agricultural investments. In this regard, particularly relevant steps for government include the alignment of growth and environmental policies and the improvement of national, regional, and local capacity for sustainable land-use planning and management, such as participatory local processes and the development of decision-support systems and incentives that facilitate the design of climate-smart agricultural landscapes.

Approaching social and environmental challenges merely from the perspective of the government's roles is necessary but insufficient, however. The collective commitment of the private sector is also required to improve the social and environment footprint of the agricultural sector.

iv) Strengthening public institutions

During the last two decades, Bolivia has established new institutions (INIAF, INSA, and EMAPA, among others) and strengthened existing ones (SENASAG) to improve the delivery of critical services to the agricultural and food sector. In light of current and future challenges and opportunities to realize the potential of agriculture and food systems in Bolivia, these efforts must continue and even intensify as the agricultural and food sector and risks evolve.

Aside from strengthening the capacity to provide key services to the sector, it is essential to strengthen the capacity for evidence-based policy making and investment planning; monitoring, policy analysis, and program evaluation; recognizing food emergencies and agriculture and food security risks; and using all

of these capacities for effective policy action and program implementation. Policy makers require effective assessments of the benefits and tradeoffs of more specific policies (related to export and input markets, price interventions, and the roles of state-owned enterprises in agriculture, for instance) as well as a broad understanding of the evidence on policies and strategies that are likely to be effective in achieving agricultural growth, competitiveness, and food security objectives.

Better data collection is a key requirement for better evidence to support better policy and planning. For example, enhanced data collection is a requirement to monitor gains in agricultural productivity at a more informative scale (from the macro-region to the departmental and lower levels) and develop better estimates of TFP.

In the short term, it is critical to continue strengthening MDRyT's capacity to perform its role critical role in defining, monitoring, and evaluating agricultural policy, while decentralized agencies strengthen their capacity for policy action and implementation. This clear definition of roles and enhanced capacities would improve the coordination and effectiveness of policy making and investments. Systematic sharing of lessons and experiences from investments and programs would help key ministries and public agencies to harmonize their efforts and also make investments more effective.

Finally, a key condition for achieving sustainable and inclusive agricultural growth is to make collaboration between the public and private sectors the basis for continued progress. Agriculture is fundamentally a private activity. The largest investments for supporting growth of the agricultural sector into the future will come from the private sector (including large, medium, and small-scale producers and processors), although public spending will also be essential. The coordination of public and private efforts opens important avenues for promoting innovation and piloting comprehensive approaches that enable the convergence of sustainable and inclusive growth objectives. This collaboration should be institutionalized in such a way that it becomes the foundation for advancing the creation of prosperity and wealth in rural Bolivia.

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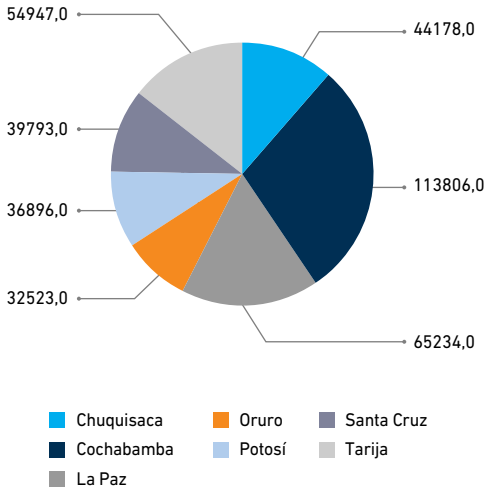
Annex 1. Irrigation and input use in Bolivia

a) Area irrigated by department. Bolivia, 2016.



b) Use of certified seed, 2015

	National production of certified seed (tons)	Supervised seeds, national and imported (tons)	Percentage of area sown with quality seed
Rice	3,182	42	23.40%
Maize	2,886	3,797	65.30%
Potatoes	9,289	119	2.90%
Quinoa	22	2	2.40%
Soybean	70,370	12,768	98.10%
Wheat	6,162	275	33.70%

c) Fertilizer consumption, average 2014-2016

Country	Fertilizer consumption (Kg per ha of arable land)
Argentina	38
Bolivia	9
Brazil	173
Chile	356
Paraguay	104
Peru	127
Uruguay	148

d) Mechanisation adoption. Bolivia, 2013-2014 (estimates)

Machine	Quantity
Chainsaw	28,444
Electric generator	12,017
Fimigator	62,214
Harvester	13,283
Laboratory flask	5,548
Milking machines	2,680
Motocultor	2,889
Peeler	19,042
Sprayer	4,485
Tractor	57,449
Water Pump	64,628

Source: a) Vice Ministry for Water Resources and Irrigation; b) IICA 2015; c) WDR; d) MDRyT, 2015

Annex 2. Data requirements and methodology for TFP and technical efficiency in agriculture

a. Data requirements for calculating TFP and SFA in the agricultural sector

To analyze evolution of the TFP, it is necessary to have a series of production and producer prices per year, department/Macro-Region and crop (or livestock). Also, to count with data on the quantity and price of inputs (intermediate inputs, capital or machinery and hired family labor) by year and department/Macro-Region.

Production information (quantities and prices) should be measured at crop or livestock level, while input information should be grouped at input level. It is preferable for this information to come from recent annual series and to be available in a disaggregated form at the department/Macro-Region level for making the analysis at this level.

The following lists show the details of the data required for analyzing the evolution of TFP for both the agricultural and livestock sectors.

Lista de datos necesarios para calcular la PTF

Agricultural Activity				
Indicator	**Level**	**Availability of information**	**Years**	**Source**
Production per year by crop (total)	Departments	Yes	1984-2016	INE/MDRyT
Average price per year by crop	Departments	No	-	-
Sown area per year by crop (total)	Departments	Yes	1984-2016	INE/MDRyT
Quantity of intermediate inputs used per year (total) (seeds, fertilizers, herbicides, fung., etc.)	Departments	No	-	-
Prices of inputs used per year	Departments	Yes	2016-2018	MDRyT
Capital stock (machinery) per year (total)	Departments	No	-	-
Machinery rental price per year	Departments	No	-	-
Quantity of hired labor per year (total)	Departments	No	-	-
Quantity of family labor per year (total)	Departments	No	-	-

Livestock Activity				
Indicator	**Level**	**Availability of information**	**Years**	**Source**
Producción de carne por año por especie (total)	Departamentos	No	-	-
Precio promedio de la carne por año por especie	Departamentos	No	-	-
Producción de leche por año por especie (total)	Departamentos	No	-	-
Precio promedio de la leche por año por especie	Departamentos	No	-	-
Producción de lana por año por especie (total)	Departamentos	No	-	-
Precio promedio de la lana por año por especie	Departamentos	No	-	-
Cantidad utilizada de insumos ganaderos importantes por año (total)	Departamentos	No	-	-
Precio de los principales insumos ganaderos por año (total)	Departamentos	No	-	-
Capital (maquinarias) por año (total)	Departamentos	No	-	-
Precio del alquiler de maquinarias por año				
Cantidad de mano de obra contratada por año (total)	Departamentos	No	-	-
Cantidad de mano de obra familiar por año (total)	Departamentos	No	-	-

Source: Author's elaboration

Data availability to perform the analysis was a limiting factor. There are no available data on average output prices per year and by crop at the departmental level; neither for total quantities of inputs (intermediate inputs, machinery, hired labor and family labor) at the departmental level. Without data on producer prices of crops at the departmental level, it is not possible to build an output and input indices. The situation is similar in the livestock sector.

b. Data requirements for calculating TFP and SFA in the agricultural sector

List of information required for analyzing Technical Efficiency

Variable	Level	Type	Availability	Source
Gross Production Value (crops)	APU	Output	Yes	ENA 2015
Crop area	APU	Inputs	Yes	ENA 2015
Expenditure on intermediate inputs	APU	Inputs	Yes	ENA 2015
Expenditure on hired labor	APU	Inputs	Yes	ENA 2015
Expenditure on machinery	APU	Inputs	Yes	ENA 2015
Number of family labor employed	APU	Inputs	Yes	ENA 2015
Membership in organization	APU	Det. of inefficiency	Yes	ENA 2015
Electrification coverage	Municipality	Det. of inefficiency	Yes	Pop. Census 2012
Accessibility index	Municipality	Det. of inefficiency	No	-
Access to telephony				
Access to technical assistance	APU	Det. of inefficiency	Yes	ENA 2015
Access to agricultural information	APU	Det. of inefficiency	Yes	ENA 2015
Non-agricultural job opportunities	Municipality	Det. of inefficiency	Yes	CENAGRO 2013
Land fragmentation index	Municipality	Det. of inefficiency	Yes	CENAGRO 2013
Crop diversification index	Municipality	Det. of inefficiency	Yes	CENAGRO 2013
Irrigation coverage	Municipality	Det. of inefficiency	Yes	CENAGRO 2013
Land titling	APU	Det. of inefficiency	Yes	MDRyT
Household size	APU	Det. of inefficiency	Yes	ENA 2015
Gender of producer	APU	Det. of inefficiency	Yes	ENA 2015
Age of producer	APU	Det. of inefficiency	Yes	ENA 2015
Education of producer	APU	Det. of inefficiency	No	
Slope	Municipality	Environmental var.	Yes	MDRyT
Soil quality	Municipality	Environmental var.	Yes	MDRyT
Altitude	Municipality	Environmental var.	Yes	MDRyT
Rainfall	Municipality	Environmental var.	Yes	MDRyT
Temperature	Municipality	Environmental var.	Yes	MDRyT

Source: Author's elaboration

Stochastic frontier and meta-frontier analyses are generally performed using survey data at the level of production units. The required data/information include: (1) quantities and prices of output and inputs (it is not always necessary to have prices, the quantities or value of output and the cost of inputs may be sufficient); (2) exogenous determinants of (in)efficiency; and (3) environmental variables affecting the meta-frontier. Most of this information is included in the data set of the ENA 2015 survey[69], such as information on the GPV, the area under cultivation, expenditure on inputs, labor use, as well as other data on potential determinants of technical efficiency in each Macro-Region such as variables of characteristics of the producer (household size, gender and age of the producer), access to information and technical assistance, and associativity.

Additional information is available from the 2013 Agricultural Census and the 2012 Population Census dataset. This specifically concerns data on access to public goods and services (irrigation and electrification), crop diversification, land fragmentation, non-agricultural job opportunities and data on the context in which each producer operates (climate, soil, altitude, etc.). The information included from both censuses is at the municipal level, in order to avoid potential endogeneity with the ENA variables at the producer level.

It would be ideal to have some indicator on accessibility to markets; however, this variable does not exist and the limited set of information available from the Bolivian road network is insufficient to construct indicators that contain sufficient information for the municipalities of the sample of producers. There is no information either at the APU level on the level of schooling of the agricultural producer.

Given that information is available at the producer level of the elements that are part of the production function (gross production value and variables of expenditure and use of inputs) and that there is an important set of variables at the municipal level of the potential determinants of efficiency, it is feasible to carry out an analysis of technical efficiency and a meta-frontier analysis for both Macro-Regions and the most important crops.

c. Detailed methodological approach for STA and MFE

The stochastic frontier analysis (SFA) is used to estimate a production frontier representing the current state of technology in the industry. The frontier also defines the maximum potential or optimum level of production of the industry. Firms or companies operate on the frontier if they are technically efficient or below the frontier if they are not technically efficient. The frontier is considered stochastic because the deviations from the frontier include a component that represents random shocks affecting the production process and another component with a specific distribution function representing technical inefficiency. The problem is how to estimate this (in) efficiency relative to the stochastic frontier when only the "deterministic" part can be estimated.

69 The National Agricultural Survey is a survey designed to collect information among agricultural producers. Information is available for 2008 and 2015 (the latest version) and this survey is expected to have some continuity in the future. The ENA has departmental inference and mainly contains information on aspects related to agricultural production. Data are available on the agricultural production and the destination thereof (consumption, domestic market, foreign market, processing, storage, etc.), sown and harvested area, quantity and price of certain inputs (seed, fertilizer, pesticide, insecticide, fungicide and herbicide), the hiring of labor and daily wages, use of tractors and machinery and rental costs. With regard to livestock, it collects information about the production (in terms of stock variation, whether by sale, birth, exchange, consumption, etc.) of cattle/sheep/goats/pigs, llamas and alpacas, and poultry and farmed birds; also, in the production and prices of livestock products such as milk, eggs, fiber and hides, and wool. However, there is no information on expenditures (or amounts) on livestock inputs. The ENA also contains information on the characteristics of the producer (gender, age), family labor, technical assistance, credit, associativity, access to irrigation, among other variables.

A linear stochastic frontier model can be expressed as follows:

$$Y_{ji} = f^{j}(X_{ji})\ e^{v_{ji} - u_{ji}},$$
$$j = 1, 2, \ldots, \mathrm{J}\ ;\ i = 1, 2, \ldots, \mathrm{Nj}$$

Where Y_{ji} denotes the production of unit "i" in group or region "j"; X_{ji} is a vector of inputs of a production function. v_{ji} and u_{ji} are the two residual components, where v_{ji} is a stochastic component (captures statistical noise) and $i.i.d\ N(0,\sigma^2)$ is assumed, and where u_{ji} it is a non-negative variable and represents the technical inefficiency of unit "i" in group or region "j". Following Caudill et al. (1995), u_{ji} is assumed with a half-normal distribution $N^{+}(0,\sigma^2_{ui})$ with a variance $\sigma^2_{ui} = \exp(Z_i, \delta_{ij})$ that is a function of the exogenous determinants of technical efficiency captured by vector Z_{ji} and an unknown parameter vector δ_j to be estimated.

Using this model, it is possible to predict u_{ji} and calculate the technical efficiency of unit "i" in group or region "j" as $TE^{j}_{i} = \exp(-U_{ji})$ (Jondrow et al., 1982).

One disadvantage of standard stochastic frontier models is that it is not possible to compare the technical efficiency of producers using different technologies, since they do not operate under the same production frontier. This complication could occur in the present study, because agriculture in different regions of Bolivia has different technologies and production systems in response to widely divergent agroclimatic conditions. Spatial differences in temperature, precipitation, soil characteristics and other production factors determine the input-output combinations that are possible for each region and therefore result in different production frontiers (O'Donnell et al. 2008). Thus, if the technical efficiency is estimated independently for each region, the results cannot be compared directly due to the heterogeneity of production technology across regions.

Recognizing this problem, Battese and Rao (2002) propose a meta-frontier approach to calculate efficiency measures that allow for comparisons between groups with different technologies. The measures they propose may be broken down into specific technical efficiency measures of groups (or regions) and technology gap ratios between different groups. This approach is complemented by Battese et al. (2004) and O'Donnell et al. (2008), which use a two-step procedure to estimate the meta-frontier. In the first stage, standard stochastic frontier techniques are used to estimate the specific frontier of each group; in the second stage, the data envelopment analysis (DEA) is used to estimate the meta-frontier. Since non-parametric methods such as DEA lack statistical inference and do not allow the identification of sources of variation among groups, we prefer a new approach proposed by Huang et al. (2014) that uses stochastic frontier techniques in the second stage to estimate a meta-frontier using a pool of regional frontier estimations of the first stage. The production function of the meta-frontier is defined by $f^{M}(X_{ji})$ and includes the previously estimated group frontiers $f^{j}(X_{ji})$. It can be expressed in the following ratio:

$$f^{j}(X_{ji};\ \beta_j) = f^{M}(X_{ji})\ e^{v^{M}_{ji} - u^{M}_{ji}}$$

The technology gap ratio, representing the distance from the production frontier to the meta-frontier, is defined as follows:

$$TGR^{j}_{i} = e^{-u^{M}_{ji}}$$

u^{M}_{ji} represents the technology gap and is assumed to have a half-normal distribution $N^{+}(0,\sigma^2_{u^{M}_{ji}})$ with variance $\sigma^2_{ui} = \exp(Z^{M}_{ji}\ \partial_j)$, which is a function of factors of the technological environment Z^{M}_{ji}.

Efficiency measures of the producers with respect to the meta-frontier are obtained by multiplying the technology gap ratio (hereinafter called technological gap) by the technical efficiency measures of producers. The resulting estimations of meta-technology efficiency (MTE) can be compared among producers and regions or groups.

$$MTE^{j}_{i} = TGR^{j}_{i}\ x\ TE^{j}_{i}$$

Annex 3. Main programs/projects providing direct support to producers/communities

Project/Program	Period/Funding	Project Objective
Rural Alliances project (PAR) I & II	First Phase: 2006-2014: US$80M Second phase: 2013-2021: US$145M	To improve accessibility to markets for small rural producers in the selected Areas by: (a) promoting productive alliances between different small rural producer organizations and purchasers; (b) empowering rural producers through the establishment and strengthening of self-managed grass-root organizations; (c) increasing access to productive assets, technology and financial services; (d) promoting more effective, responsive and accountable service organizations at the local level; and (e) enhancing environmental sustainability of productive practices
Community Investment in Rural Areas Project Additional Financing (PICAR)	2011-2019: US$100M	To improve access to sustainable basic infrastructure[70] and services for the most disadvantaged rural communities selected in some of the poorest municipalities of Bolivia. This would be accomplished through a participatory process in which empowered rural communities identify, prepare, implement, and maintain development and productive infrastructure sub-projects that respond to their priorities, based on the Community Driven Development approach.
Economic Territorial Development with Inclusion (DETI)	2011-2017: US$25M	To promote local productive development and adaptation to climate change of small agricultural and forestry producers of indigenous communities and peoples, through comprehensive support for agricultural, agroforestry and other non-agricultural productive initiatives and the strengthening of institutional capacities
Direct Support for the Creation of Rural Agri-food Initiatives (CRIAR) I & II	2016-2021: US$62M	To increase smallholders' agricultural income and food security through productivity improvements triggered by technological adoption
Economic Inclusion for rural families and communities (ACCESOS)	2013-2019: US$59M	To reduce poverty by improving the living conditions of rural communities through: i) strengthening capacities for sustainable management of natural resources, ii) development of agricultural and non-agricultural economic enterprises and iii) access to financial and non-financial services, for their own development. This objective was complemented in December 2013 as an additional ASAP (Adaptation Program for Small Scale Agriculture) grant resources were approved to promote adaptation to climate change in 16 municipalities targeted by the program
PRO Camelids	2016-2022: US$39M	To improve living conditions of families and productive economic organizations linked to the South American camelids complex while ensuring sustainable management of natural resources.
Plan VIDA	2011-2016: US$15M	To improve the livelihoods of rural households residing in vulnerable municipalities in the departments of Potosí and Cochabamba.

70 Infrastructure is principally understood as productive, non-commercial investments at community and family level.

Project/Program	Period/Funding	Project Objective
Development Indigenous Fund (FDI)	NA	To improve the productive development of indigenous peoples original, peasants and intercultural and Afro-Bolivian communities (2017 – 2020) by strengthening local production that contribute to Food Security with Sovereignty.
National Fund for Integral Development (FONADIN)	NA	Generate sustainable and participatory Integral Development, fostering community and institutional self-management capacities, including private investment to eliminate the causes of poverty, exclusion and environmental deterioration. Its specific objectives are: • Diversify the productive and economic base by generating jobs. • Contribute to the improvement of the living conditions of the population of the areas covered by the National Strategy for Integral Development with Coca. • Promote the development of community and institutional participation and management capacities.

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