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**Agricultural
productivity**



Key messages

Over the past six decades, agricultural output in Latin America and the Caribbean (LAC) has grown at an annualized rate of 2.8%, increasing the region's share of global production from 9.4% in 1961 to 12.3% in 2022.

Input accumulation and use explain 53% of the increase in agricultural output between 1961 and 2022, while total factor productivity (TFP) accounted for the remaining 43%.

TFP growth has been uneven across LAC subregions. Since 1961, TFP nearly tripled in Brazil and increased by a factor of 2.2 in Mesoamerica, while in the Andean countries and the Southern Cone it grew by 91% and 72%, respectively. In the Caribbean, TFP was stagnant over the period.

Labor-productivity gaps with higher-income countries—and even within LAC—reflect lower land endowments per worker, limited agricultural capital, and the region's TFP lag.

Poorly functioning land markets—marked by widespread informality—lead to misallocation of resources across farms and a size distribution skewed toward smaller ones. These conditions hinder economies of scale, restrict access to credit, and discourage mechanization.

Irrigation is essential for raising agricultural yields and will become even more critical under climate change. While the region has expanded irrigation access and adopted more advanced systems (such as sprinkler and drip irrigation), there is room for improvement.



Digitalization is a key enabler of better production practices. By expanding data generation and processing, it strengthens decision-making and enables process automation—reducing costs and improving input efficiency.



Climate change threatens to reduce agricultural productivity in the region. However, spatial relocation of production and shifts in crop composition can help mitigate—and potentially fully offset—the negative impacts.



Policy priorities to boost agricultural productivity include improving land-market functioning through property formalization; expanding access to financial instruments—particularly developing the agricultural insurance market; upgrading infrastructure (transport, electricity, irrigation and digital); promoting innovation and mechanization; and reducing trade barriers.

Agricultural productivity¹

Introduction

The agricultural sector plays a central role in the region due to its contribution to overall production, its linkages with other sectors through input-output relationships, and its importance as a source of foreign exchange, as shown in Chapter 2 of this report. That chapter also examined the evolution of three key determinants of production: land, labor, and capital.

This third chapter focuses on analyzing the evolution of productivity in the agricultural sector, its main determinants, and the policies that could help raise it. It also explores how two major global forces may significantly affect agricultural productivity in the region: the Fourth Industrial Revolution and climate change.

Digitalization and artificial intelligence (AI) can be powerful tools for increasing output and productivity. By enabling the use and processing of large volumes of data generated through digital devices—such as drones, soil sensors, and satellite

imagery—they support process automation and improvement.

Climate change is altering average temperatures and rainfall and drought patterns, with direct implications for agricultural productivity. These impacts, however, are heterogeneous: negative in some areas but beneficial in others. Given this heterogeneity, the ability to reallocate production away from areas that will lose productivity toward those likely to gain—and to adjust the mix of cultivated products—will be crucial to limiting losses or maximizing potential gains.

The final section of the chapter addresses the set of policies needed to promote agricultural productivity. Key priorities include improving land-property regimes, expanding access to financial markets and infrastructure, and fostering innovation and digitalization in the sector.

¹ This chapter was written by Lian Allub and Manuel Toledo with research assistance from María Pía Brugiafreddo.

The evolution of agricultural output and productivity

Agricultural production in Latin America and the Caribbean (LAC) has grown substantially over the past six decades, increasing by a factor of more than five—equivalent to an annualized growth rate of 2.8%. In contrast, global agricultural output merely quadrupled over the same period. As a result, the region's share of global production rose from 9.4% in 1961 to 12.3% in 2022.²

This growth, however, has not been uniform across the region. Output increased eightfold in Brazil, while in Mesoamerica and the Andean³ countries it rose by factors of 5.5 and 5.8, respectively. In the Southern Cone, production grew by a factor

of 3.7, and in the Caribbean, by 1.9. At the country level, beyond Brazil, strong performers include Guatemala, Bolivia, Belize, and Costa Rica, with output increases ranging from a factor of 8.8 in Guatemala to 7.1 in Costa Rica.



Agricultural output in LAC increased fivefold over six decades—outpacing global growth—but performance varied markedly across countries and subregions

Drivers of agricultural output growth

A natural question that emerges is what drove this growth. To answer this question, a growth-accounting exercise is used to separate the contribution of inputs (capital, labor, land, and intermediate inputs) from that of total factor productivity (TFP), which measures how efficiently these inputs are combined to produce agricultural goods.⁴ This distinction is essential, as it helps assess the nature of growth—whether it stems from greater accumulation and use of inputs or from using them more efficiently. Graph 3.1 presents the results for the region as a whole and for each subregion. The exercise shows that input growth—including land, employment, the stock of physical capital, and intermediate inputs⁵ used—accounted for 57% of the increase in agricultural output over 1961–2022, while TFP contributed the remaining 43%.

TFP growth and, to a lesser extent, increased use of intermediate inputs and capital accumulation have been the main drivers of the substantial rise in agricultural output in the region since the 1960s.

There are marked differences across subregions. In the Caribbean, TFP contributed only marginally; output growth was almost entirely explained by inputs—especially capital, which accounted for 53% of the increase—followed by intermediate inputs (23%) and land expansion (17%).

2 These figures are based on data from the United States Department of Agriculture (USDA), which report the total value of crop, livestock, and aquaculture production using constant 2015 global agricultural prices, expressed in thousands of purchasing power parity (PPP) dollars.

3 This category includes Bolivia, Colombia, Ecuador, Peru, and Venezuela. It does not include Argentina and Chile, which are part of the Southern Cone.

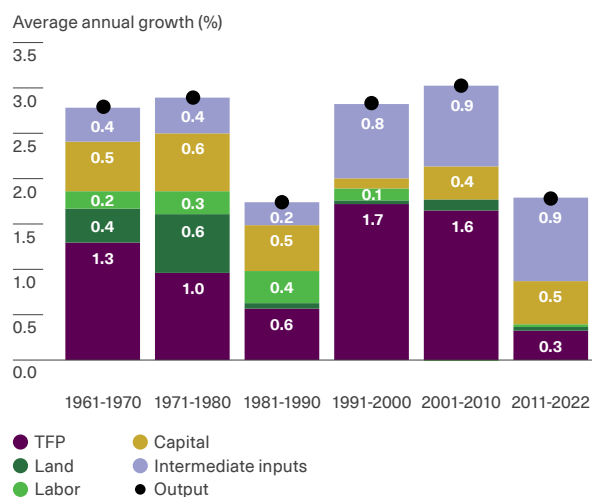
4 This indicator of production efficiency captures intangible elements such as technology, management practices, and the allocation of land both across farms and across agricultural activities and crops. TFP may increase as a result of technological progress, improved management practices, or better allocation of inputs.

5 These include inputs used in production, such as fertilizers and feed.

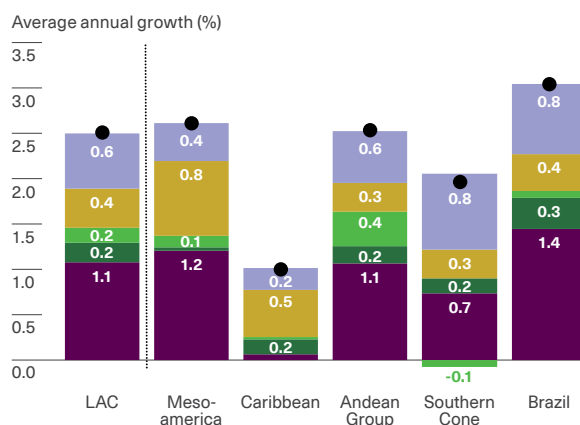
Graph 3.1

Growth accounting of agricultural output in Latin America and the Caribbean, 1961–2022

Panel A.
By decade



Panel B.
By world subregions, 1961–2022



Source: Authors based on data from the USDA (2025).

In the Southern Cone, although TFP made a significant contribution of 38%, intermediate inputs were the primary driver of production growth, accounting for 42%. In contrast, in Mesoamerica, capital accumulation explained nearly one-third of growth—double the contribution of intermediate inputs—while TFP played a central role, contributing 46%. Finally, in the Andean countries, labor stood out, contributing 15%, exceeding the contribution of capital at 12%.

Given the importance of TFP in driving agricultural output growth in the region, it is useful to examine its trajectory more closely. Between 1961 and 2022, agricultural TFP increased by 122%—a higher rate than in major agricultural producers such as Australia, Canada, and the United States, where it doubled. Compared with other world regions, LAC's TFP growth also surpassed that of Oceania, Europe, and Africa, where increases reached 69%, 62%, and 31%, respectively.

However, it remained below Asia's 155% increase, driven largely by China, where productivity rose by a factor of 3.3 (Graph 3.2).

Agricultural output growth since 1961 has been driven largely by input accumulation and use, although total factor productivity accounted for 43% of the increase

The expansion of agricultural TFP in the region is explained primarily by technological change. This progress largely reflects the transfer of technology from developed countries, including the adoption of genetically modified crops and zero-tillage or no-till systems, as well as investment in research and

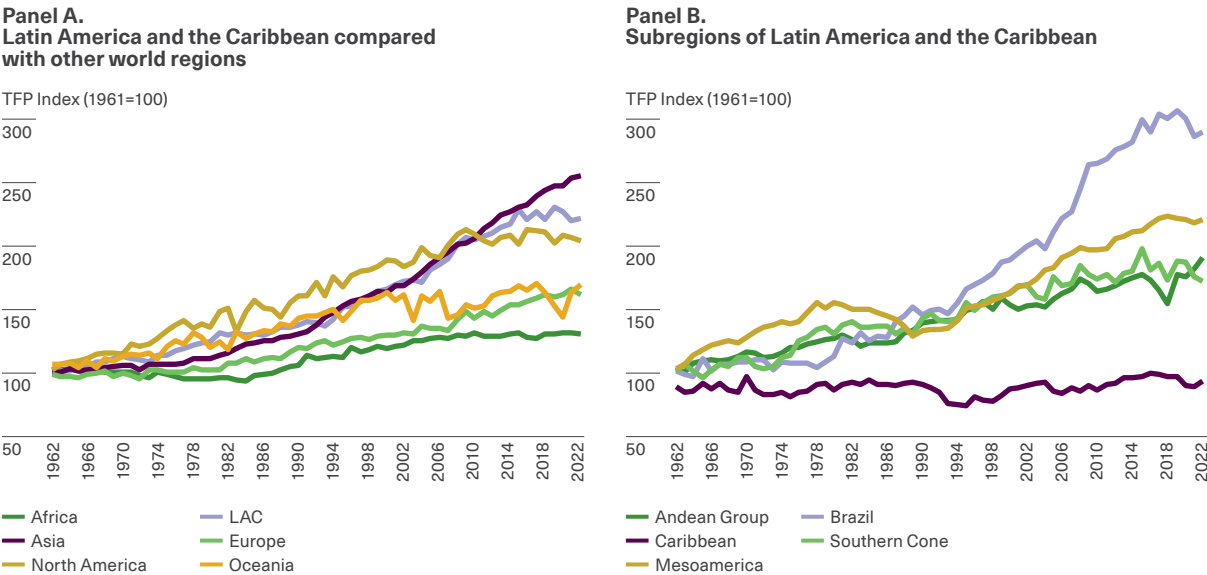
development (R&D).⁶ However, between 1990 and 2010—when TFP growth accelerated (1.8% annually compared with 1.1% in 1961–1990)—the increase in this indicator was driven mainly by efficiency gains (Ludeña, 2010).

After 2010, when TFP growth stalled at 0.3% per year and accounted for only 18% of agricultural production growth (the lowest contribution in the past six decades), both technological progress and efficiency improvements slowed due to a combination of factors. These include the limited adoption of precision agriculture, the effects of climate change, and the expansion of the agricultural frontier into less suitable land. This led

to more intensive use of agricultural materials—such as fertilizers and agrochemicals—to sustain output growth, raising long-term environmental sustainability concerns, including soil degradation and biodiversity loss (Salazar et al., 2024).

At the subregional level, TFP performance has been far from uniform. In Brazil, TFP nearly tripled since 1961, increasing by a factor of 2.9, which accounts for much of the region’s overall productivity trajectory. In Mesoamerica, TFP doubled by a factor of 2.2, while in the Andean countries and the Southern Cone it grew by 91% and 72%, respectively. In stark contrast, TFP in the Caribbean remained stagnant over the period analyzed.

Graph 3.2
Trends in total factor productivity, 1961–2022



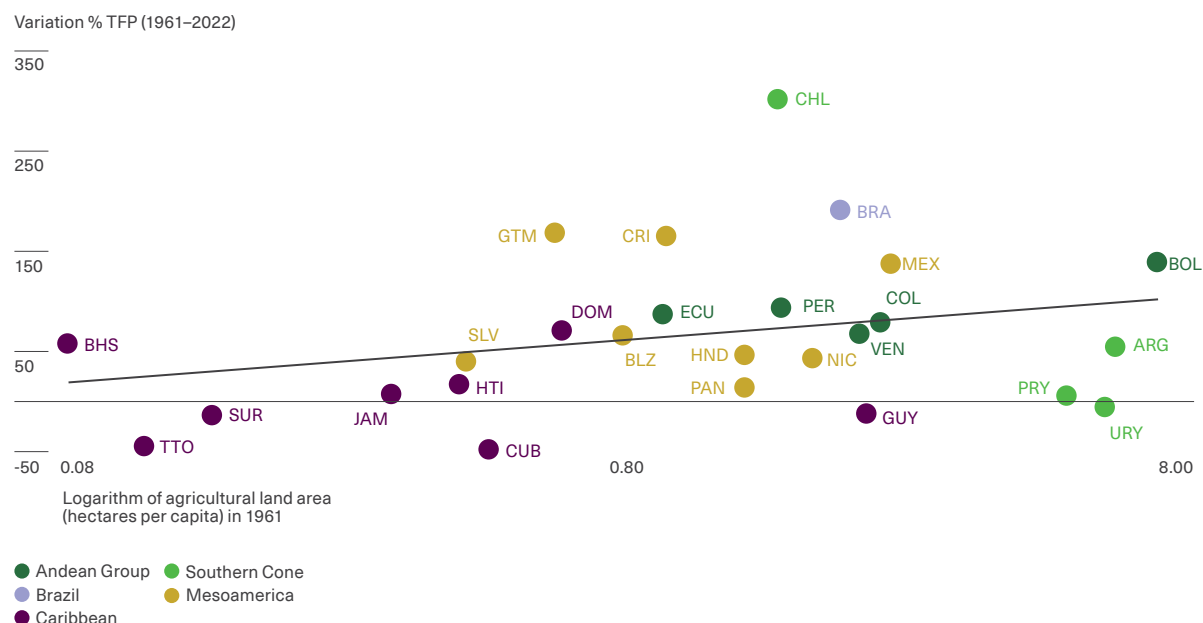
Source: Authors based on data from the USDA (2025).

6 An example of R&D investment as a key driver of productivity growth is Brazil’s experience with Embrapa, a public scientific research corporation established in 1973 to develop locally relevant science and technology. Akerman et al. (2025) show the significant impact on agricultural productivity in municipalities with greater exposure to Embrapa. The authors also estimate that public investment in R&D increased national agricultural productivity by 110% (see Box 3.7 for further details).

The substantial heterogeneity across LAC countries and subregions in agricultural TFP growth rates is explained largely by differences in per-capita agricultural land abundance. This positive relationship between TFP growth and land abundance is shown in Graph 3.3. In countries with abundant land,⁷ TFP grew at an average annual rate of 1.1% between 1961 and 2022, compared with 0.6% in land-constrained countries. This suggests

that a wider availability of land—and the larger scale of production it enables—supports greater agricultural productivity gains in the region.⁸ This pattern has important implications for food security and poverty reduction: slower productivity growth in land-scarce countries, most of which are already net food importers, may exacerbate food insecurity and limit reductions in rural poverty (Ludeña, 2010).

Graph 3.3
Growth in total factor productivity relative to land abundance



Source: Authors based on data from the FAO (2025I) and USDA (2025).

7 Countries are defined as land-abundant when they have more than 1.4 hectares (ha) of agricultural land per capita in 1961, the regional median. This group includes Argentina, Bolivia, Brazil, Chile, Colombia, Guyana, Mexico, Nicaragua, Peru, Uruguay, and Venezuela. Using the median of agricultural land per worker as the criterion (in this case, in 1991, due to the lack of agricultural employment data for 1961) yields similar results.

8 This pattern, however, is not observed in the rest of the world, particularly in Asia, where TFP grew at a lower rate in land-abundant countries.

Beyond these country-level differences, it is important to underscore the sharp contrast between TFP growth in the agricultural sector and TFP performance in LAC's overall economy. Although the region's aggregate TFP grew at a pace similar to that of developed countries until the late 1970s, it experienced a steep decline during the 1980s, followed by stagnation beginning in the 1990s. As a result, aggregate TFP in LAC fell by roughly

10% between 1961 and 2023, implying a negative contribution of TFP to regional economic growth over this period (Álvarez et al., 2018).

Despite the significant increase in agricultural TFP in recent decades, this indicator does not provide information on LAC's productivity level relative to other countries or regions. The following sections focus on conducting this comparative analysis.

Labor productivity

Before examining regional TFP levels, it is useful to focus on agricultural labor productivity. The most common metric is agricultural value added per worker, which captures the total value of production after deducting the value of intermediate inputs. This measure reveals a large gap relative to more developed countries and regions. On average, value added per worker in LAC amounts to only 14% of the level observed in the United States, 31% of the European average, and 22% of the OECD average.⁹ When the metric used is gross output per worker—which does not net out intermediate inputs—the gap is even wider: on average, LAC reaches just 9%, 27%, and 18% of the productivity levels of the United States, Europe, and the OECD, respectively. This reflects the greater share of intermediate inputs in production in more developed countries, particularly in the United States.

Graph 3.4 shows cross-regional labor-productivity differences as well as within-region heterogeneity. LAC displays productivity levels similar to those of Asia and three times higher than those of Africa (Panel A). Within the region, however, differences are substantial (Panel B). For example, the ratio between the 75th and 25th percentiles is 3.7 (USD 12,300 in The Bahamas versus USD 3,300 in Peru). Nonetheless, intraregional dispersion is smaller than in Africa, Asia, and Oceania, and broadly similar to that of Europe.

Underlying these gaps is a deep internal heterogeneity, characterized by the coexistence of highly efficient production systems alongside large segments of subsistence or low-capital agriculture. At the aggregate level, labor productivity is inherently linked to structural factors that determine the endowment and allocation of production inputs. In LAC, the agricultural sector still accounts for a relatively high share of total employment, farms tend to operate at smaller scales (in terms of land area), and—critically—the amount of land available per worker is limited.

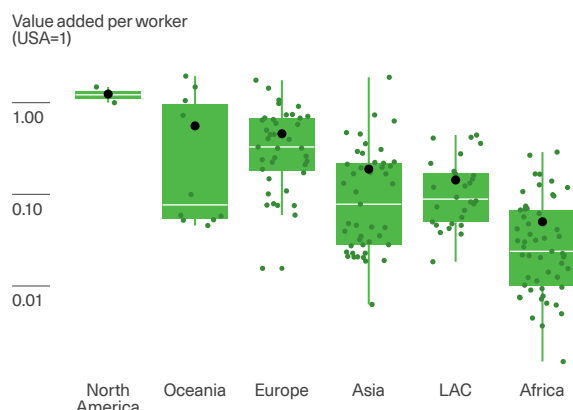
● ●
Labor productivity in the region is low due to structural factors, including limited land available per worker

⁹ These figures, as well as those presented in the remainder of this subsection, are based on FAO data and are calculated as averages over the most recent 10 years available (2014–2023). Value added is expressed in constant 2015 U.S. dollars (USD). Due to data limitations, both value added and employment include agriculture, forestry, and fishing (ISIC code A). Gross output refers to the gross value of agricultural production, expressed in constant 2014–2016 purchasing power parity (PPP) dollars.

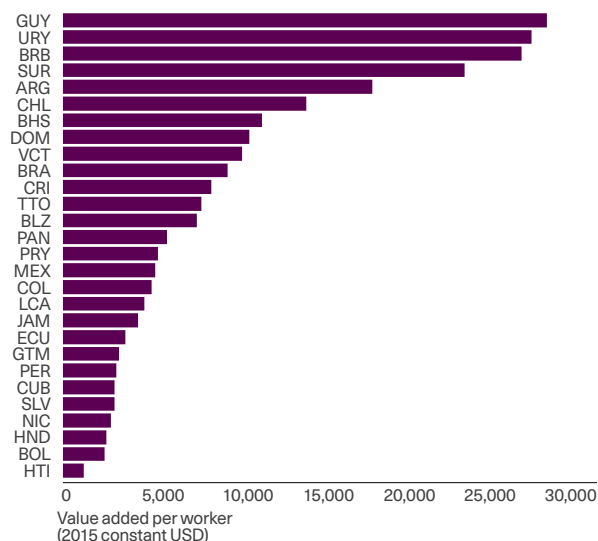
Graph 3.4

Agricultural labor productivity, average 2014–2023

Panel A.
Latin America and the Caribbean compared
with other world regions



Panel B.
Countries in Latin America and the Caribbean



Note: Panel A reports value added per worker (relative to the United States) on a logarithmic scale. The boxplot shows, for each region, the median (white line), the interquartile range (IQR), the whiskers defined by $Q1 - 1.5 \times IQR$ and $Q3 + 1.5 \times IQR$, and outliers. The black dot indicates the mean for each region.

Source: Authors based on data from the FAO (2025f, 2025g).

Total factor productivity

To better understand the sources of productivity differences between LAC and higher-income countries, as well as among countries within the region, it is necessary to look beyond labor productivity and decompose it into its fundamental components. The gap in value added per worker can be attributed to two main factors: differences in the endowment of production inputs (physical capital per worker and land per worker) and differences in TFP.

On the one hand, land endowment per worker in the region is very low. The average agricultural worker in LAC has access to roughly 14 hectares

(ha), equivalent to only 9% of the level observed in the United States and around 20% of the OECD average. These figures, however, conceal substantial intraregional heterogeneity. In the Southern Cone and Brazil, land per worker averages 52 ha, whereas in the Andean countries it falls to around 11 ha, in Mesoamerica to 6 ha, and in the Caribbean to just 5 ha. At the country level, Uruguay leads the region with 105 ha per worker, followed by Argentina with 73 ha. At the opposite end of the spectrum, in addition to Caribbean countries, Ecuador, El Salvador, and Guatemala all have fewer than 3 ha per worker.¹⁰

¹⁰ This heterogeneity is compounded by significant gender inequality. On average, the land area held by women amounts to 42% of that registered to men in Brazil, 80% in Chile, 40% in Costa Rica, 34% in Ecuador, 57% in Nicaragua, and 67% in Peru (Nobre & Hora, 2017).



Worker recording agricultural data on a tablet during avocado harvest in Colombia.

On the other hand, LAC also has low levels of agricultural capital (machinery, irrigation infrastructure, etc.) per worker. On average, capital per worker represents only about 5% of the level observed in the United States, nearly 6% of the OECD average, and around 8% of the European average. There are, again, notable differences within the region. Uruguay and Argentina have capital per worker levels equivalent to 20% and 17% of those in the United States, followed by Suriname, The Bahamas, and Chile at 15%, 13%, and 10%, respectively. At the lower end, Haiti's capital per worker does not reach 1% of the U.S. level. Moreover, nine countries fall between 1% and 2%, including Bolivia, Colombia, Cuba, Ecuador, Jamaica, Mexico, Nicaragua, Peru, and Trinidad and Tobago.

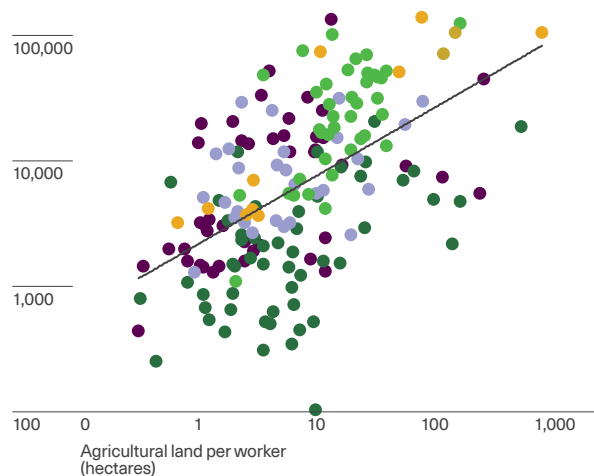
Graph 3.5 confirms the close positive correlation between these factor endowments and labor productivity. Countries with abundant land and capital per worker, such as Uruguay and Argentina, consistently appear in the upper productivity quadrants, while those with greater constraints in both inputs—including Haiti and several Caribbean and Central American countries—cluster at the bottom. This evidence underscores that a significant share of the region's agricultural productivity gap can be traced to these structural shortages in production inputs.

Graph 3.5

Factor endowments and agricultural labor productivity, average 2014–2023

Panel A. Land per worker

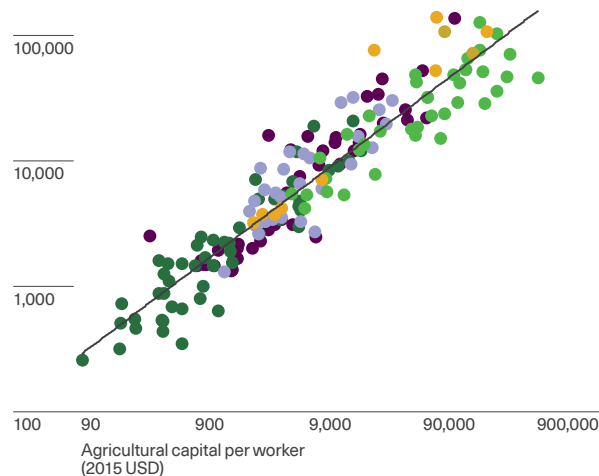
Value added per worker
(2015 USD)



● Asia ● Europe
● Africa ● North America
● LAC ● Oceania

Panel B. Capital per worker

Value added per worker
(2015 USD)



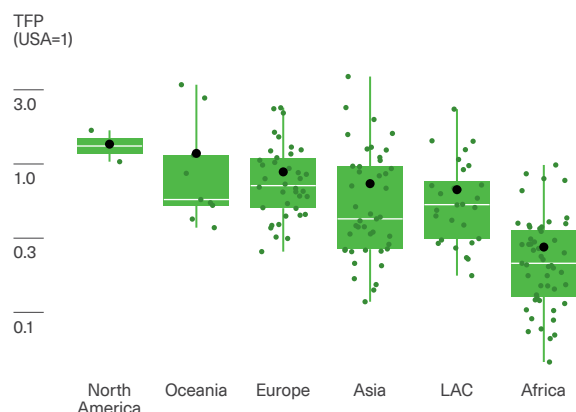
Note: In both graphs, the axes are shown on a logarithmic scale.

Source: Authors based on data from the FAO (2025f, 2025g, 2025i, 2025l).

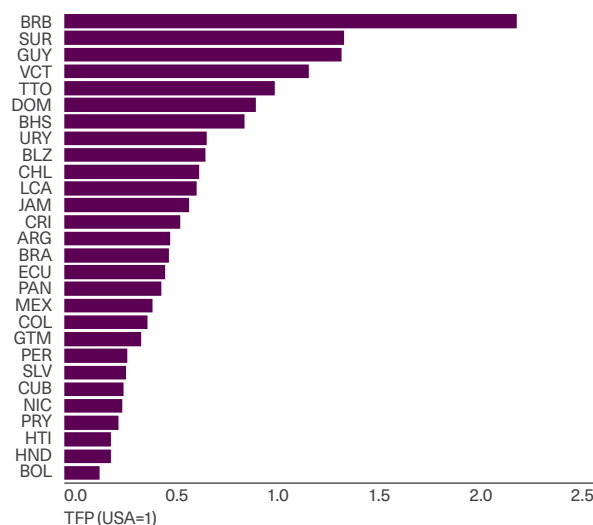
Graph 3.6

Total factor productivity in the agricultural sector, average 2014–2023

Panel A.
Latin America and the Caribbean compared
with other world regions



Panel B.
In Latin American and Caribbean countries



Note: Panel A shows TFP, relative to the United States, on a logarithmic scale. The boxplot shows, for each region, the median (white line), the interquartile range (IQR), the whiskers defined by $Q1 - 1.5 \times IQR$ and $Q3 + 1.5 \times IQR$, and outliers. The black dot indicates the mean for each region.

Source: Authors based on data from the FAO (2025f, 2025g, 2025i, 2025l).

The labor-productivity gap is also meaningfully driven by the region's TFP lag (Adamopoulos & Restuccia, 2014). Estimates based on FAO data on value added, employment, capital, and agricultural land for 2014–2023—using a standard production function—show that agricultural TFP in the region lags behind that of high-income countries (panel A of Graph 3.6). On average, it stands at around 65% of the level observed in the United States, 76% of the European average, and 62% of the OECD average.¹¹

This analysis reveals substantial disparities within LAC. Countries such as Barbados, Guyana, Saint Vincent and the Grenadines, Suriname, and Trinidad and Tobago exhibit levels of TFP comparable to those of high-income economies. In contrast,

Bolivia, Cuba, El Salvador, Haiti, Honduras, Nicaragua, and Paraguay lie in the bottom quartile of the distribution, with TFP levels of 30% or less relative to the United States—reaching a low of 18% in Bolivia (panel B of Graph 3.6).

A natural question is how much of the labor-productivity gap documented above is explained by differences in TFP, capital per worker, and land per worker. To answer this, a development-accounting exercise is applied. In the case of LAC, the exercise indicates that, on average, 56% of the gap in value added per worker relative to the United States is explained by low TFP. The capital gap accounts for 21%, while the low land endowment per worker represents the remaining 23%. This implies that if countries in the region were able to close the TFP

¹¹ These percentages are calculated using each country's average TFP over the 2014–2023 period. Ten-year country averages are then used to compute the regional and OECD averages.

gap entirely, labor productivity would reach 45% of the U.S. level, rather than the current 14%.¹²

It is important to emphasize that TFP affects production not only directly, but also indirectly through its influence on capital and land per worker. Lower TFP is associated with both smaller agricultural land areas per worker and lower levels of capital per worker. This reflects weaker capital accumulation and a greater absorption of workers into agricultural activities—patterns illustrated in Graph 3.7, which shows the positive relationship

between TFP and capital and its negative relationship with agricultural employment as a share of the population.

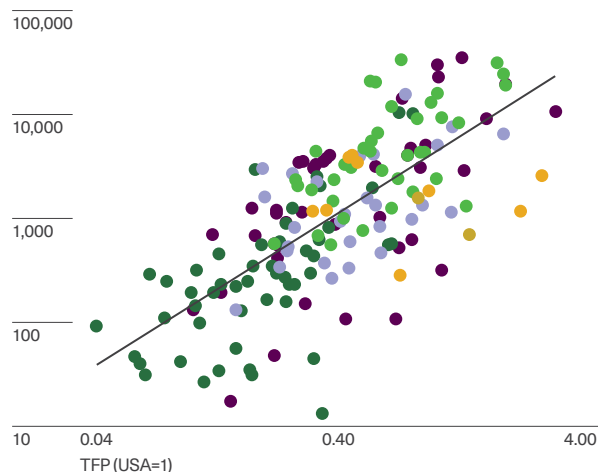
● ●
The productivity gap with developed countries reflects both lower capital and land per worker and a lag in production efficiency

Graph 3.7

Total factor productivity and factor endowments in the agricultural sector, average 2014–2023

Panel A. Capital–land ratio

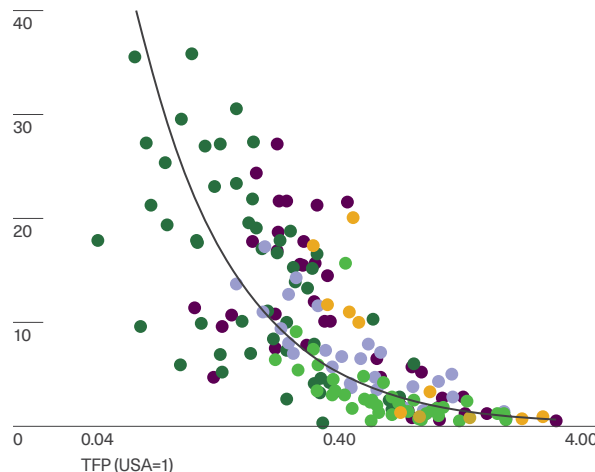
Agricultural capital per unit of land (2015 USD/ha)



● Asia
 ● Europe
 ● Africa
 ● North America
 ● LAC
 ● Oceania

Panel B. Employment–population ratio

Agricultural employment as a share of the population (%)



Note: In both panels, the horizontal axis shows total factor productivity (TFP), relative to the United States, on a logarithmic scale. In Panel A, the vertical axis shows agricultural capital stock per hectare of agricultural land, on a logarithmic scale. In Panel B, the vertical axis shows agricultural employment as a percentage of the total population.

Source: Authors based on data from the FAO (2025f, 2025i, 2025j, 2025l).

¹² It is important to note that this analysis does not account for differences in human capital among agricultural workers. As a result, these differences are implicitly captured in the calculation of TFP.

The role of intermediate inputs

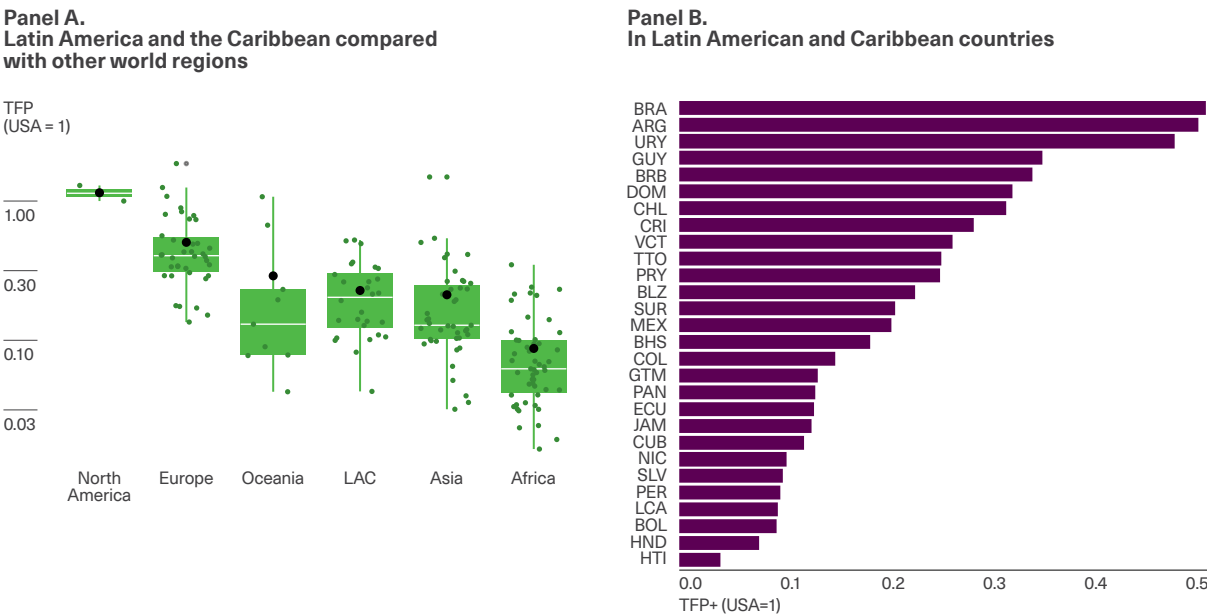
The preceding analysis, based on value added, overlooks the impact of intermediate inputs on production—a key component of agricultural output growth in the region. To address this limitation, a similar analysis is carried out using gross agricultural production.¹³

This approach allows for the derivation of a productivity measure that, while adjusted for land and capital endowments per worker, captures both TFP and the intensity of intermediate-input use. This expanded metric is referred to as TFP+. When this measure is applied, the productivity gap in LAC is even clearer: the regional average of TFP+ reaches only 22% of the level observed in the United States,

45% of the European average, and 34% of the OECD average, revealing a substantial lag, as shown in Graph 3.8.

The wider productivity gap captured by TFP+ is largely explained by the lower share of intermediate inputs in agricultural production across the region. Available data (discussed in more detail below) confirm that their use in LAC is below that of advanced economies. As a result, the observed productivity gap reflects not only lower efficiency in the use of primary factors (capital, land, and labor) but also limited use of intermediate inputs, which further constrains production.

Graph 3.8
Agricultural productivity (TFP+), average 2014–2023



Note: Panel A shows TFP+, relative to the United States, on a logarithmic scale. The boxplot shows, for each region, the median (white line), the interquartile range (IQR), the whiskers defined by $Q1 - 1.5 \times IQR$ and $Q3 + 1.5 \times IQR$, and outliers. The black dot indicates the mean for each region.

Source: Authors based on data from the FAO (2025f, 2025i, 2025l, 2025m).

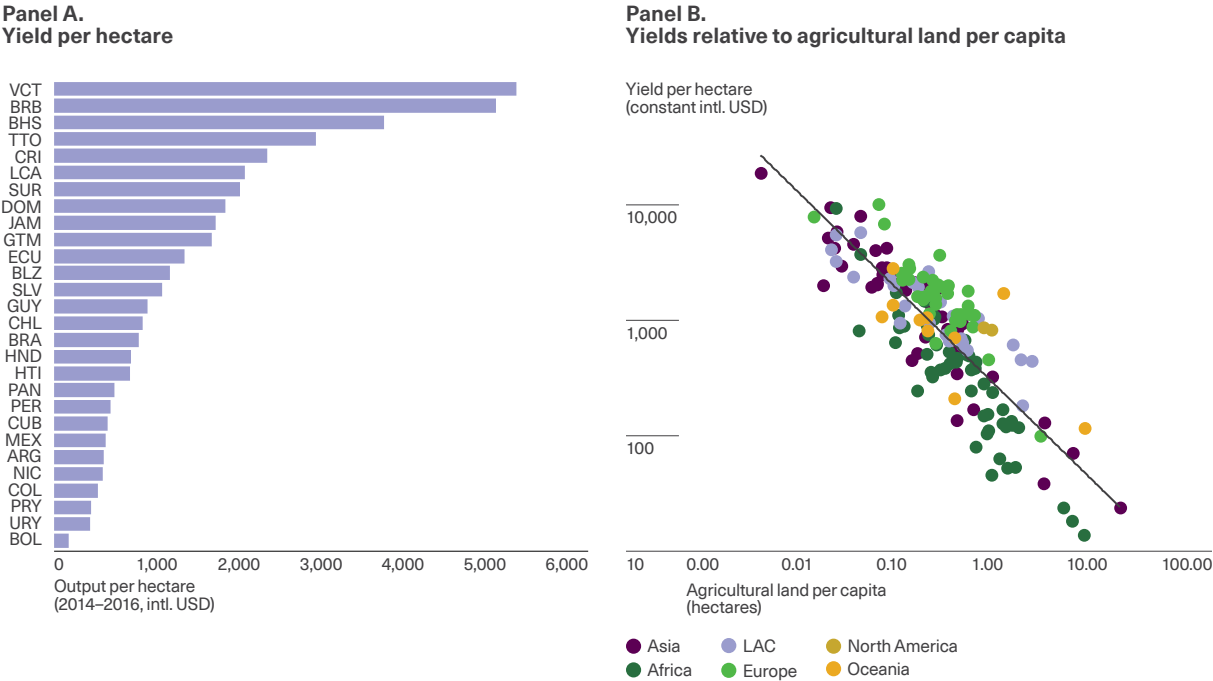
13 Unlike value added, gross agricultural output is adjusted for PPP and excludes forestry and fishing production.

To examine more closely the role played by intermediate inputs in the agricultural productivity gap, it is useful to analyze differences in agricultural yields, measured as the gross value of production per hectare of agricultural land.

As shown in Graph 3.9 (panel A), yield disparities across countries in the region are substantial and are explained primarily by differences in per-capita

land abundance (panel B). Caribbean countries such as The Bahamas, Barbados, and Trinidad and Tobago—with the lowest agricultural land endowment per capita (around 0.03 ha)—record the highest yields in the region, while countries such as Bolivia, Paraguay, and Uruguay—with the largest agricultural land area per capita (between 3 ha and 4 ha)—record the lowest yields.

Graph 3.9
Agricultural yields, average 2014–2023



However, when controlling for land abundance—that is, holding agricultural land per capita constant across countries—the Southern Cone and Brazil not only record the highest land-adjusted yields

in the region, but also rank among the highest globally (Graph 3.10).¹⁴ Caribbean countries, by contrast, tend to have the lowest adjusted yields in the region, with the notable exception of Guyana.

14 This land-adjusted yield corresponds to the residual from a regression of yields per hectare on agricultural land per capita.

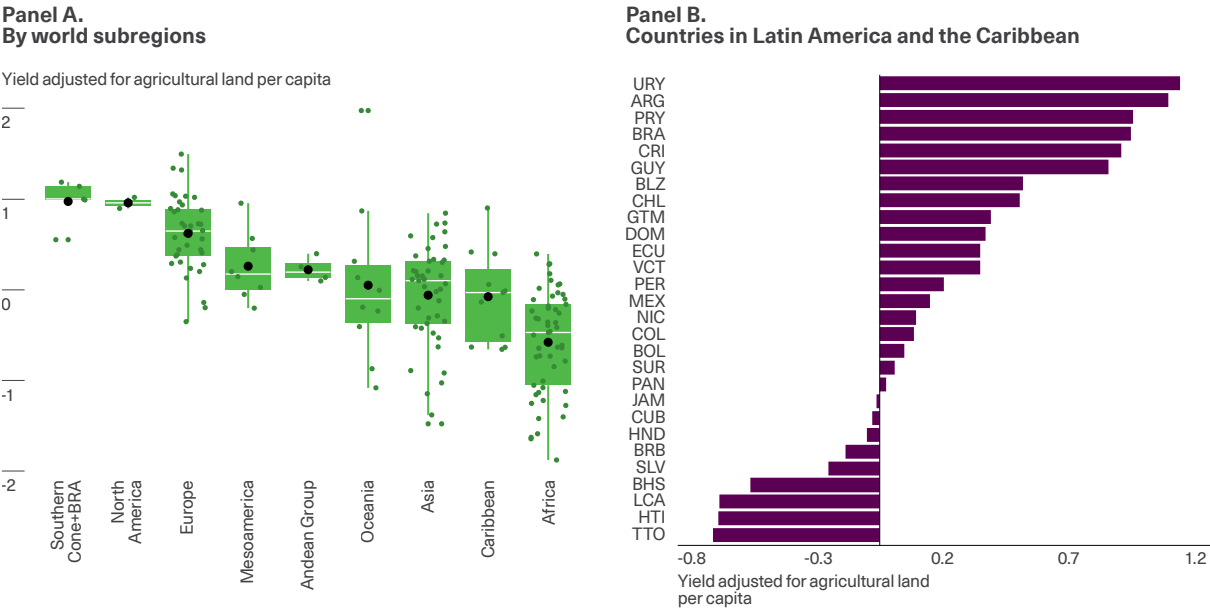
Countries in the Andean group and Mesoamerica generally fall in the middle of the distribution, except for Belize and Costa Rica, which are in the top quartile.

This suggests that the Southern Cone, Belize, Brazil, Costa Rica, and Guyana either have higher-quality land, make more intensive use of inputs, or apply better agricultural practices and technologies than the rest of the region. Indeed, the data show a strong positive relationship

between land-adjusted yields and inputs such as capital and fertilizer use.¹⁵

● ●
The productivity gap widens once intermediate inputs are taken into account, as their intensity of use in the region remains below that of advanced economies

Graph 3.10
Agricultural yields adjusted for land abundance, average 2014–2023



Note: Panel A shows yields adjusted for agricultural land per capita on a logarithmic scale. The boxplot shows, for each region, the median (white line), the interquartile range (IQR), the whiskers defined by $Q1 - 1.5 \times IQR$ and $Q3 + 1.5 \times IQR$, and outliers. The black dot indicates the mean for each region.

Source: Authors based on data from the FAO (2025j, 2025l, 2025m).

15 In a regression of yield per hectare on agricultural land per capita, capital per unit of land, the intensity of fertilizer and pesticide use, and the area under irrigation, the results show that—beyond the negative effect of land endowment—only the level of capital per unit of land and fertilizer use have statistically significant (positive) effects on yields. The remaining estimated coefficients are not statistically different from zero, which may reflect correlation among explanatory variables, such as between fertilizer use and irrigation.

In summary, the analysis in this subsection shows that the deep agricultural productivity gap facing LAC has multiple dimensions. Beyond the clear—though heterogeneous—shortfalls in capital per worker and low levels of land per worker, the evidence indicates that cross-country productivity differences are explained largely by the intensity of input use. While the lag in pure efficiency (TFP) remains a critical factor, accounting for more than

half of the gap in value added per worker, this gap is magnified when the low use of intermediate inputs is taken into account. Understanding the determinants of—and barriers to—the adoption of improved agricultural practices and more modern technologies in the region is essential to closing the gap with global leaders and consolidating the agricultural sector as a pillar of regional development.

Structural and technological drivers of agricultural productivity in Latin America and the Caribbean

The region has favorable endowments for agriculture—with the potential to exceed those of more developed countries—yet there is a notable lack of correlation between a country's actual output per hectare and its potential yield based purely on natural suitability. This disconnect indicates that factors beyond geography play a more decisive role in shaping current productivity outcomes, suggesting that countries exploit their natural advantages with varying degrees of effectiveness (Adamopoulos, 2025). The sizeable yield gap—the difference between current observed yields and those that could be achieved with improved inputs—points to substantial untapped potential in many LAC countries, driven by differences in the adoption and efficiency of modern agricultural techniques.¹⁶

Inefficiencies in the spatial allocation of production and suboptimal crop choices within countries also contribute to productivity disparities. These decisions regarding input use, the location of agricultural activity, and crop selection are, in turn, shaped by broader factors such as institutional quality, market access, infrastructure constraints, and other economic frictions, all of which vary widely across the region.

The enabling environment, which encompasses a broad set of conditions, also influences farmers' technological choices and directly affects productivity. Access to markets and support institutions plays a critical role: participation in output markets, access to credit (particularly from private sources), and formal land tenure through titling are all associated with higher productivity. These challenges are more pronounced for women farmers, who face greater barriers to land ownership and access to agricultural capital. By contrast, natural factors such as adverse climatic conditions and susceptibility to soil erosion have a negative impact on production. Risk management—related, for example, to rainfall variability—also affects productivity outcomes, sometimes leading farmers to adopt less productive but safer strategies. Household characteristics, including farmers' education levels and support from sectoral associations, further contribute to the observed productivity differences.

Ultimately, productivity levels are determined by the interaction between inputs, the enabling environment, and resulting technological choices, as well as by the degree of technical efficiency achieved by farmers. The evidence points to the existence of a technological frontier, with farms operating at varying distances from it, reflecting

16 Adamopoulos (2025) finds that improved input use would result in potential yields that are 2.4 times higher than current yields on average across LAC countries, and 1.65 times higher in high-income countries.

differences in technical efficiency. Larger farms tend to operate closer to this frontier, exhibiting higher technical efficiency, possibly due to fewer constraints or better access to optimal practices.

In contrast, smaller farms are more sensitive to environmental and institutional constraints, leading to wider productivity variation linked to their specific initial conditions.

Informal land tenure, land markets, and their (mis)allocation

Latin America and the Caribbean is one of the regions with the highest levels of inequality in land distribution and tenure worldwide, a situation compounded by widespread legal insecurity. As shown in Chapter 2, land ownership in the region is highly concentrated in large agricultural farms, alongside a high prevalence of small farms.

This agrarian structure, polarized between large estates and smallholdings, conceals a highly inefficient allocation of land, reflected in its low level of utilization. Fossati (2025), in a study covering Argentina, Colombia, and Panama, finds that the harvested area represents only 23%, 20%, and 12% of total land area in these countries, respectively, well below the 43% observed in the United States.

One explanation is that vast portions of land within large farms remain idle or are devoted to low-productivity activities, such as extensive livestock farming, despite being suitable for more profitable and labor-intensive crops. At the other end of the spectrum, smallholdings concentrate large numbers of workers on plots that are too small to achieve economies of scale or adopt modern technologies. As a result, land misallocation is accompanied by an inefficient allocation of labor within the agricultural sector.

The distribution of farms by size is closely linked to the high level of informality in land tenure that characterizes the region. This informality contributes significantly to the malfunctioning of land markets and creates barriers to a more efficient allocation of land. In this context, the lack of formal land titles and the predominance of small producers are not isolated phenomena.

One of the most significant consequences of informal land tenure is its restrictive effect on land market transactions. This limits the ability to exploit economies of scale, particularly in settings where mechanization and capital-intensive agriculture could substantially raise productivity. As a result, land remains fragmented into suboptimal plots, undermining productivity. In addition, informal producers who are unwilling or unable to cultivate their land are often compelled to continue using it solely to preserve their rights, preventing its transfer to more productive users. This dynamic is reflected, for example, in the extremely low rates of agricultural land renting in LAC—clear evidence of the dysfunctions affecting land markets in the region, as shown in Graph 3.11.

The implications for labor allocation are also significant. Informal land tenure creates a form of labor attachment to land, as noted by De Janvry et al. (2015), which discourages households from seeking employment outside the agricultural sector or migrating—even when returns outside agriculture are higher—due to the risk of losing land rights through absence. This rigidity leads to an excess supply of labor in low-productivity agricultural activities and an underutilization of human capital in more profitable sectors. It also limits the ability of rural households to diversify their income sources and adapt to market opportunities.

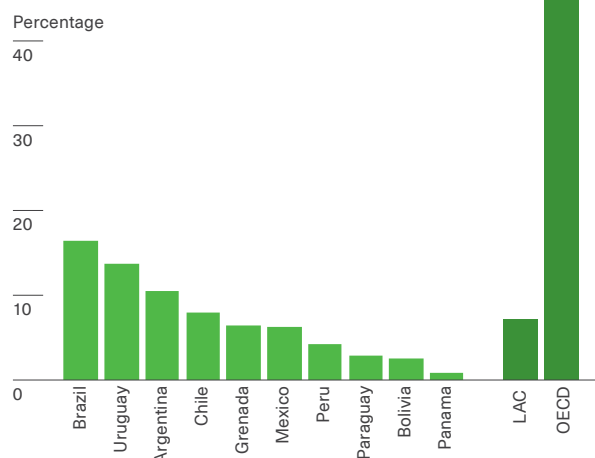


Center-pivot irrigation over a corn field in Argentina.

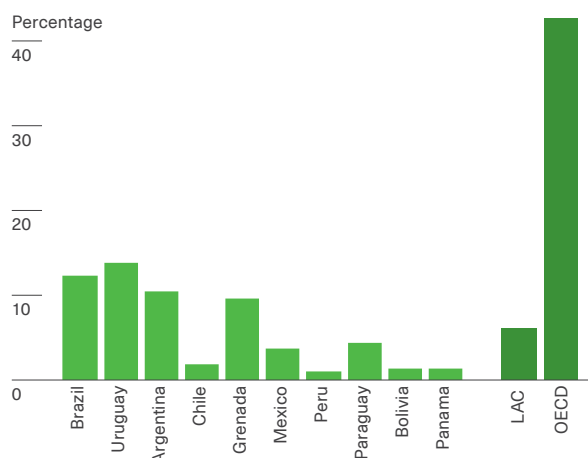
Graph 3.11

Share of farms and land under rental arrangements

Panel A.
Farms under rental arrangement



Panel B.
Land under rental arrangement



Source: Authors based on data from the FAO (2025c).

High levels of tenure informality hinder land markets, discourage long-term investment, and restrict access to credit, perpetuating low productivity

Informality also discourages investment in capital. Insecure tenure weakens incentives to undertake

long-term investments in land, such as building irrigation systems, planting perennial crops (coffee, cocoa, fruit trees), or improving soil health, since those working the land cannot be certain they will reap the returns from these investments. More critically, the absence of formal land titles prevents land from being used as collateral, restricting access to credit from the formal financial system and, in turn, limiting the ability to acquire technology and other inputs needed to raise productivity.

Machinery use and quality

Motorized mechanization in LAC began with a substantial delay relative to North America and Europe, where the transition from animal traction to tractors was largely completed in the first half of the twentieth century. In the region, this process accelerated during the second half of the century. For example, “the number of tractors per 1,000 hectares of arable land nearly tripled, rising from

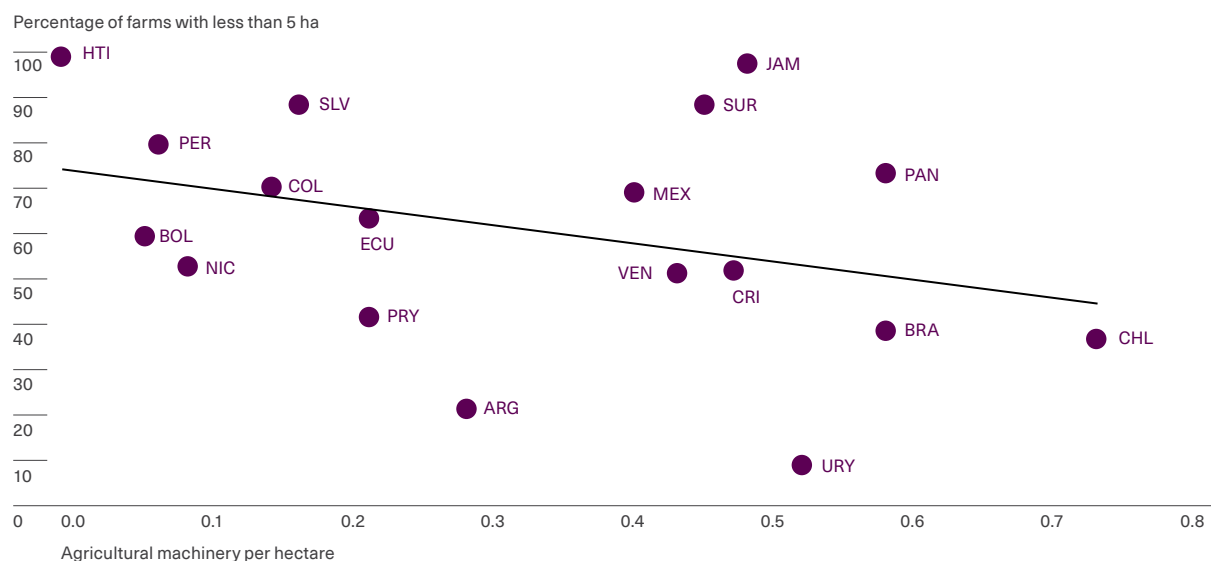
5 in the 1960s to 14 in the 2000s” (FAO, 2022b). This modernization was critical, as the tractor not only replaced animal power but also catalyzed innovation across a wide range of implements, such as seeders, harvesters, and threshers, reducing physical labor demands and improving the timeliness of agricultural operations.

Despite this progress, the region as a whole continues to lag behind. Chapter 2 of this RED shows that LAC has significantly lower levels of agricultural machinery. This finding is confirmed by Fossati (2025), who reports that only 38% of farms in Argentina have tractors, compared with 79% in the United States. In Colombia, 15% of farms report owning machinery, while in Panama the figure is around 20%. This lag is further reflected in the fact that the marginal returns to adopting machinery in LAC are higher than in most other regions of the

world (Bravo Ortega & Lederman, 2004; Elverdin et al., 2018).

Machinery adoption also varies widely within the region, both across countries and across farms of different sizes (ECLAC et al., 2017; FAO, 2022b). Countries where farms are smaller on average tend to have lower machinery stocks per worker, as noted by Elverdin et al. (2018). In addition, as shown in Graph 3.12, countries with a higher share of small farms (below 5 ha) make less intensive use of machinery per hectare.

Graph 3.12
Machinery use and farm size, 2019



Note: Agricultural machinery is measured in horsepower. This figure is divided by total agricultural land to obtain average agricultural machinery use per hectare.

Source: Authors based on data from the FAO (2025c) and the U.S. Department of Agriculture processed by Our World in Data (USDA, n. d.b).

The high cost of modern machinery, along with designs often tailored to large-scale farms, makes it inaccessible or unprofitable for most small farmers in the region, who lack the minimum scale needed to justify such investments. For example, in a study of the state of Piauí in Brazil, Da Silva et al. (2018) find that the use of agricultural

machinery among small producers is almost nonexistent due to their limited purchasing power and small farm size.

Another key factor behind low levels of agricultural mechanization in the region is limited access to financing. Small producers, who account for a

substantial share of the regional agricultural sector, face significant barriers to accessing formal credit due to their limited ability to provide collateral, the informality of their operations, and the lack of financial instruments tailored to the agricultural production cycle. As a result, investment in machinery is often out of reach, even when it could significantly raise productivity and reduce reliance on labor.

This constraint is even more acute for women farmers: their access to credit is extremely limited, with rates of 4% in Peru, 5% in Ecuador, 11% in Nicaragua, 12% in Brazil, and 13% in Chile. In addition, many of their productive activities are oriented toward subsistence or are marketed through community channels without formal records, preventing them from systematically demonstrating income in ways that financial institutions require (Nobre & Hora, 2017).

These limitations are compounded by inadequate rural infrastructure and limited digital connectivity, as shown in Chapter 8 of this report. Many farmers—especially in remote areas—have restricted access to road networks, electricity, and internet services, all of which are critical for the installation and effective operation of modern agricultural machinery.

The lack of specialized support and logistics services for machinery maintenance and repair, along with the limited availability of trained technicians and appropriate spare parts, further discourages the adoption of mechanized technologies. In addition, in several countries in the region, rental or shared-use machinery services are scarce, forcing small farmers to consider

individual ownership as the only option despite the high costs involved.



The region lags behind in agricultural mechanization, constrained by the high cost of machinery, the limited scale of small farmers, and restricted access to financing

Another major obstacle is the low level of technical education and limited access to agricultural extension services. Many producers lack the knowledge required to select, operate, and properly maintain agricultural machinery, leading to inefficient use, higher risks of premature deterioration, and in some cases, complete abandonment of these technologies. This situation is exacerbated by the limited availability of targeted training and technical assistance programs to support farmers throughout the technology adoption process.

Finally, public policies aimed at promoting agricultural mechanization tend to be weak, fragmented, or altogether absent. Where initiatives do exist, they are often implemented in an uncoordinated manner across different government agencies, without a long-term vision or effective coordination. This lack of an integrated approach limits the ability to overcome existing barriers and to create an enabling environment for inclusive and sustainable mechanization in the agricultural sector.

Irrigation

Water is a fundamental input for agricultural activity. As shown in Graph 3.13, yields under irrigation are higher than rainfed yields across all regions.¹⁷

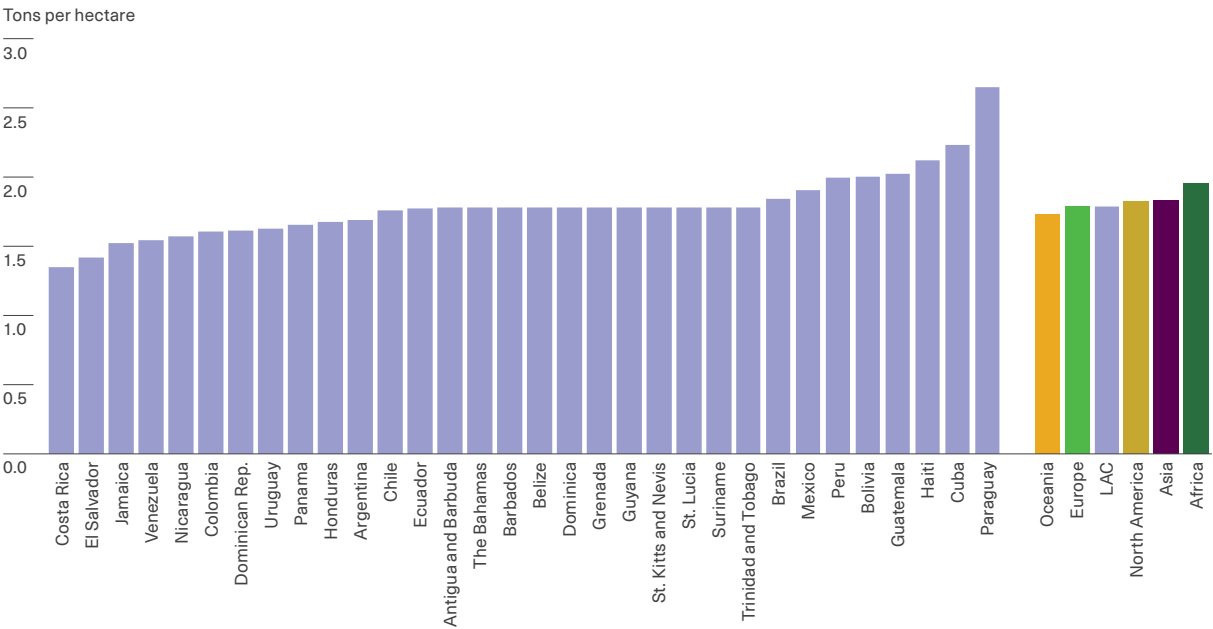
17 CAF estimated an infrastructure gap for climate-resilient agriculture and irrigation of USD 56 billion between 2020 and 2030, and USD 60 billion between 2030 and 2040 (CAF–VCPE–GDUAEC, 2023).

The development of irrigation systems first requires access to a water source—such as rivers, reservoirs, or groundwater. A significant share of public investment in irrigation infrastructure is devoted to off-farm (inter-farm) infrastructure, which enables water to be conveyed from these sources to farms. Box 3.1 describes CAF initiatives aimed at promoting this type of irrigation infrastructure.

Once access to water resources is secured, different on-farm irrigation systems can be deployed, with varying levels of efficiency and cost depending

on rainfall patterns, climate conditions, water availability, and crop type, among other factors. This dependence on multiple variables makes comparisons of irrigation availability and intensity across regions less straightforward. For example, in the Atacama Desert in Chile, in arid areas of Peru, or in North Africa and the Middle East, agricultural activity would be almost unviable without some form of irrigation, whereas in northern Europe, where rainfall is abundant, artificial irrigation systems are less necessary.¹⁸

Graph 3.13
Ratio of irrigated to rainfed crop yields, 2022



Source: Authors based on data from the FAO (2025k).

18 Correlating precipitation levels with agriculture-related water stress results in a negative relationship, reinforcing the idea that irrigation availability has multiple determinants and is difficult to analyze in a comparative framework.

Box 3.1

CAF initiatives in off-farm irrigation

Off-farm irrigation infrastructure is an essential component of sustainable agricultural development. These investments make it possible to store water during the rainy season and distribute it efficiently during dry periods, improving access to water resources and optimizing their use. In doing so, they strengthen productivity, sustainability, and the resilience of crop and livestock systems to climate variability. CAF -Development Bank of Latin America and the Caribbean- supports governments across the region in the design, financing, and implementation of this type of strategic infrastructure.

The projects described below illustrate the potential and benefits of these initiatives for promoting rural development and strengthening food security in the region.

Alto Mao Irrigation Canal, Valverde Province (Dominican Republic)

Overview and objectives. This project, scheduled for implementation in the municipality of Mao (Valverde Province), aims to expand the area under irrigation, improve productivity, and strengthen the competitiveness of the agricultural sector. It includes the construction of hydraulic works to enable efficient and controlled water distribution to areas currently not under cultivation, as well as improvements in water management within the existing Mao–Gurabo irrigation system. The project forms part of an integrated approach that combines infrastructure with capacity-building activities and environmentally sustainable watershed management.

Irrigation infrastructure components. The physical component is implemented through three lines of investment:

- Main conveyance network. Approximately 14 km of gravity-fed pressurized piping designed to convey a flow of 10 m³/s to the transfer system.
- Transfer system consisting of a 1 km pipeline transporting a flow of 6 m³/s to the existing Mao–Gurabo canal, strengthening its hydraulic capacity.
- Secondary conveyance network and reservoir connection. Approximately 18 km, linking the transfer system to reservoirs from which water is distributed to different agricultural subsectors.

The project also includes complementary components accompanying the infrastructure investment, such as beneficiary capacity building and actions aimed at sustainable watershed management.

Scope and beneficiaries. The project will benefit 10,550 hectares, of which 40% correspond to newly irrigated areas and 60% to areas with improved irrigation.

Program for the Development of New Irrigated Areas (Argentina)

Overview and objectives. This completed program aimed to develop new irrigated areas by sustainably increasing the availability and quality of water resources. Its objectives included expanding agricultural supply, improving productivity, and strengthening the sustainability of water use. In addition to infrastructure investments, the program included training activities for beneficiary farmers.

Irrigation infrastructure components. The physical component was implemented through two lines of investment:

- Productive conversion in the Toro River tobacco-growing area (Salta): Improvements to treatment works (filters and desanders), water intake (intake structure on the Toro River), and conveyance (gravity-fed canal networks). These works expanded regulation capacity, increased system efficiency, significantly reduced groundwater extraction, and strengthened productive sustainability.
- Improvements in the Guaycurú-Iné basin (Chaco): Construction of regulation and storage works through a lagoon-based irrigation system, rehabilitation of existing canals, installation of gates, and construction of lined canals to enable new irrigated areas.

The program also included complementary components that accompany the infrastructure investment, such as training activities for beneficiaries of the financed irrigation works, as well as institutional strengthening of the entities responsible for ensuring the sustainability of investments and the proper operation of collective irrigation systems.

Scope and beneficiaries. The program benefited 10,500 hectares, of which 34% correspond to newly irrigated areas in Chaco and 66% to areas with improved irrigation in Salta.

Dam Program (Bolivia)

Overview and objectives. This program, currently under implementation, aims to increase agricultural production and productivity per hectare and per beneficiary household by expanding the volume of water available through the construction of reservoirs, conveyance works, and the deployment of technified irrigation systems. It also seeks to contribute to the structural reduction of rural poverty by expanding irrigated areas for small producers.

Irrigation infrastructure components. The physical component is being implemented through the construction of dams and associated systems. The program includes three completed dams and three additional dams scheduled for completion by 2026. It encompasses the optimization of studies, supervision, and construction of dams, as well as conveyance and distribution systems, together with the implementation of environmental management measures.

The program also includes complementary components alongside the infrastructure investment, such as the development of structural and non-structural measures to protect water sources within watersheds, institutional strengthening, technical assistance for beneficiaries, and support for data processing and the implementation of the National Dam Safety Plan.

Scope and beneficiaries. The program will benefit approximately 10,000 families in communities with high poverty rates and will expand the irrigated area by an additional 8,000 hectares beyond those already under irrigation.

Source: Prepared by Jorge Ecurra.



CAF Action.
Scan the QR code to learn more about irrigation projects supported by CAF.

There are several methods for irrigating crops. The oldest and least capital-intensive is surface irrigation, such as flood or furrow irrigation. This method—mainly for rice, cereals, and forage crops—tends to be less efficient (around 40%),¹⁹ due to losses from evaporation, percolation, and runoff.²⁰ Sprinkler irrigation is the next method and consists of systems that simulate rainfall. It is more efficient (between 50% and 70%), as it allows for greater control over the irrigated area and can be automated, reducing the losses described above, although it requires higher upfront investment. Sprinkler irrigation is used mainly for tubers, such as potatoes, and for legumes. Finally, localized irrigation—either drip or subsurface—represents the most water-efficient method (between 80% and 90%) and can also be automated. Its main drawback is the high initial cost. This system is commonly used for fruit trees, olive groves, and vineyards, as well as for some horticultural crops and greenhouse production.²¹

Technified irrigation systems (sprinkler and drip) significantly increase agricultural yields relative to surface irrigation. Their effectiveness lies in more efficient water distribution and use, the possibility of fertigation,²² and the reduction of water stress and crop diseases. Although these systems require higher investment and more technical management, the gains in yields and water-use efficiency often far exceed the costs when applied to high-value crops. In Latin America and the Caribbean, surface irrigation (traditional or flood irrigation) remains the most widely used system, although the adoption of technified irrigation is expanding.

As shown in Graph 3.14, LAC is the region of the world that has experienced the largest increase in irrigated area over recent decades, with the area equipped for irrigation expanding by a factor of 3.5 between 1961 and 2022. This trend is observed

across all subregions, albeit at different speeds. While the share of irrigated area increased fivefold in the Southern Cone and Brazil, it rose by a factor of 2.5 in Mesoamerica. When measured as a share of cultivated land, the irrigated area increased from 8% to 17% over this period, making LAC the region with the second-highest proportion of irrigated land after Asia. Within LAC, the Andean subregion shows the highest share of irrigated land relative to cultivated area (30%), while the Southern Cone and Brazil display the lowest (10%). In terms of water stress, LAC is the region with the second-lowest contribution of agriculture to overall water stress, at 13.6%. Although this indicator has been rising steadily, it remains below the levels observed in North America (16%), Europe (17%), and Asia and the Pacific (24%).

Looking ahead, irrigation will play an increasingly central role. Rising temperatures and greater temperature volatility associated with climate change will increase water demand for agricultural production. Meeting this higher demand will require the adoption of efficient and sustainable irrigation systems.



LAC has led global growth in irrigated area in recent decades, although surface irrigation still predominates, and further progress toward more efficient technified systems is needed

19 Irrigation efficiency is measured as the share of applied water that effectively reaches the crop root zone. The efficiency values are taken from Nikolaou et al. (2020).

20 Runoff refers to water that flows over the soil surface without being absorbed by crops, while percolation refers to water that infiltrates beyond the crop root zone.

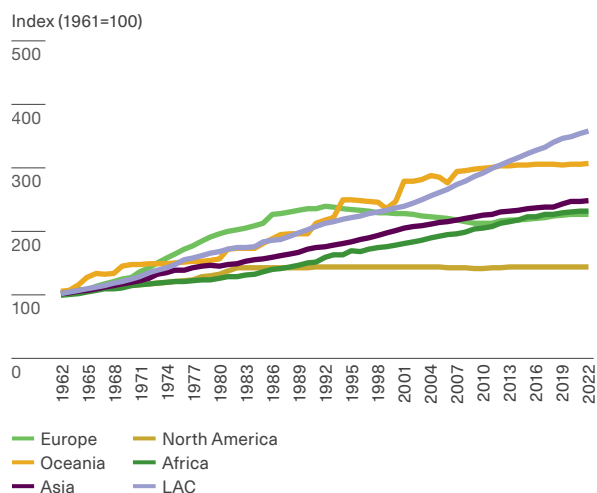
21 For example, Garriga (2022) shows that in Spain more than 90% of irrigated olive groves and non-citrus fruit use drip irrigation; nearly 80% of irrigated tubers and legumes use sprinkler irrigation; and more than 50% of forage crops rely on surface irrigation.

22 Fertigation is a technique that allows soluble fertilizers and nutrients to be applied directly to crops through the irrigation system, increasing input-use efficiency and enabling more uniform application.

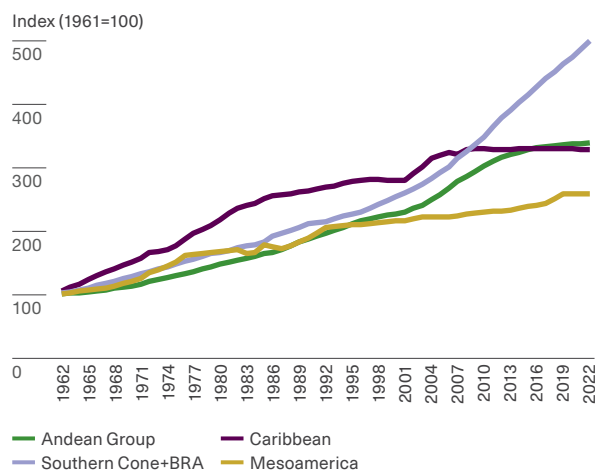
Graph 3.14

Area equipped for irrigation, 1961–2022

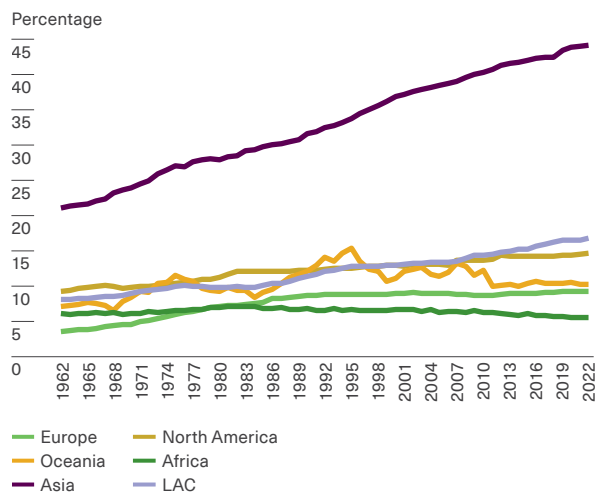
Panel A.
Index values in Latin America and the Caribbean compared with other regions



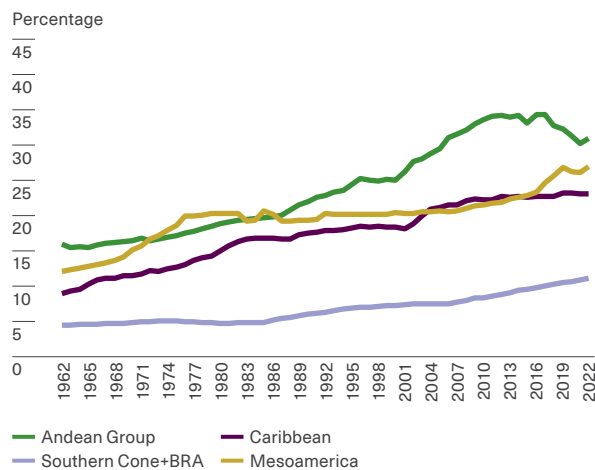
Panel B.
Index values in subregions of Latin America and the Caribbean



Panel C.
Percentage of cultivated area in Latin America and the Caribbean compared with other regions



Panel D.
Percentage of cultivated area in subregions of Latin America and the Caribbean



Note: Graph A.3.1 in the appendix to this chapter, available in the online edition of RED, presents the values of area equipped for irrigation in thousands of hectares and as a percentage of cultivated area for each LAC country in 2022.

Source: Authors based on data from the USDA (2025).

Use of high-quality intermediate inputs

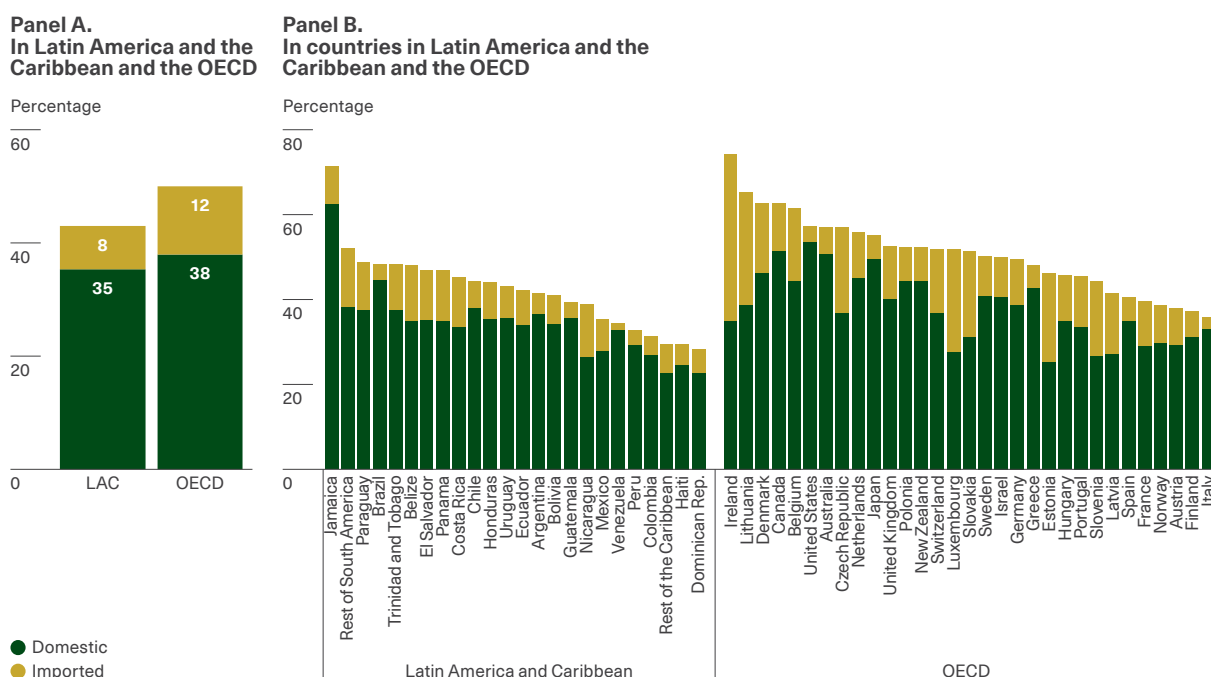
Compared with the OECD, the agricultural sector in LAC makes less intensive use of inputs. Graph 3.15 shows that intermediate input consumption, measured as a share of agricultural output, stands at 43% in LAC, compared with 50% in the OECD. This gap is driven mainly by lower use of imported inputs, which may reflect distortions such as trade barriers. At the same time, there is substantial heterogeneity within the region. In some countries, such as Jamaica and Paraguay, intermediate input use is comparable to that of the best-performing

OECD countries, while in others—such as Haiti and the Dominican Republic—it is significantly lower.

As shown in Graph 3.16, the ratio of intermediate inputs (as a share of output) between LAC and the OECD is below one in almost all agricultural subsectors. This not only indicates that the lower intensity of intermediate input use is widespread but also points to larger distortions relative to the OECD, as documented by Álvarez et al. (2018) for the full set of economic subsectors.

Graph 3.15

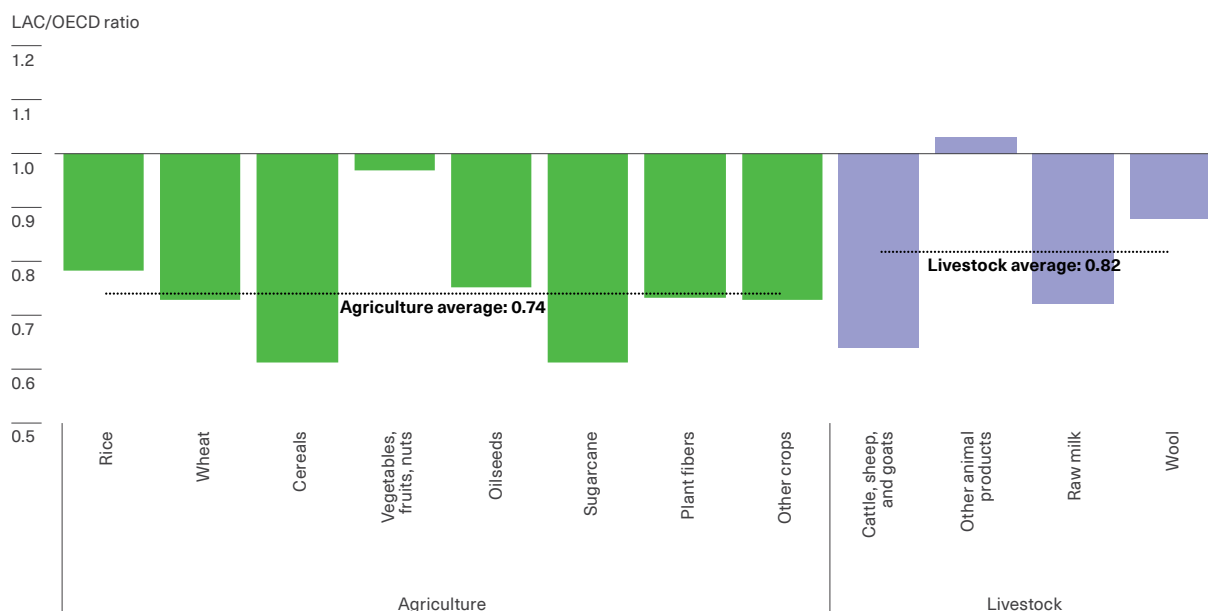
Intermediate consumption as a share of agricultural output, 2017



Note: The graph shows the share of the value of agricultural output accounted for by intermediate consumption, broken down into domestic and imported components. Regional values are calculated as the simple average of the countries in each region.

Source: Authors based on data from Aguiar et. al (2022).

Graph 3.16
Sectoral intermediate consumption, 2017



Note: The ratio of intermediate input consumption (domestic and imported) to output is calculated for each sector and country. Simple averages are then computed for LAC and the OECD for each sector. Finally, the ratio between LAC and the OECD is calculated for each sector.

Source: Authors based on data from Aguiar et. al (2022).

Fertilizers and pesticides

A large body of research identifies fertilizer application as one of the key drivers of the wide yield gaps observed across crops (Aramburu Merlos et al., 2015; Guilpart et al., 2017). As shown in Graph 3.17, fertilizer use—measured in kilograms per hectare (kg/ha)—has increased substantially since the early 1960s in all regions of the world except Europe. In LAC, fertilizer use (inorganic plus organic nitrogen) increased roughly ninefold, rising from 22 kg/ha in 1961 to about 200 kg/ha today. This increase is driven primarily by inorganic fertilizers, whose use rose from 9 kg/ha to approximately 160 kg/ha over the period.

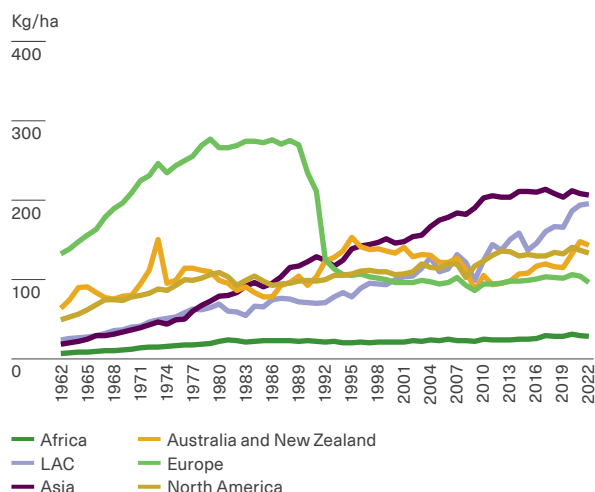
Relative to other regions, fertilizer use growth in LAC is surpassed only by Asia, where fertilizer application increased twelvefold. The expansion observed in LAC is explained to a large extent by Brazil, where fertilizer intensity rose by approximately fourteen times between 1961 and 2022, with particularly rapid growth after 2009, when it increased by more than 2.5 times.

Within the region, fertilizer use declined sharply in the Caribbean after 1990, leaving current levels close to those observed in 1961. Fertilizer use has also remained relatively stagnant over the past two decades in the Andean Group and over the past three decades in Mesoamerica. By contrast, fertilizer use in the Southern Cone has increased nearly eightfold since 1961.

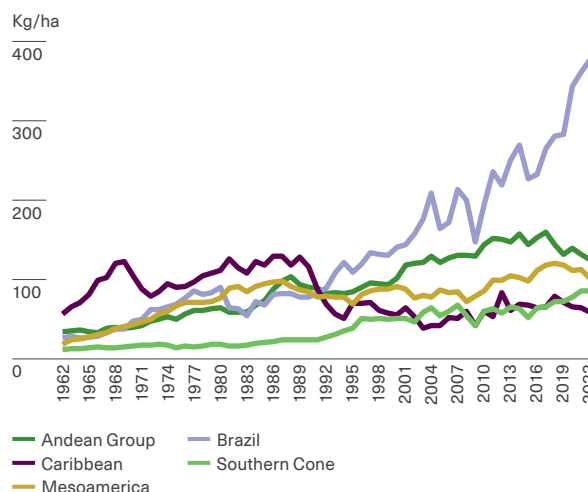
Graph 3.17

Evolution of fertilizer use in agriculture, 1961-2022

Panel A.
Latin America and the Caribbean compared
with other world regions



Panel B.
Subregions of Latin America and the Caribbean



Source: Authors based on data from the USDA (2025).

Although fertilizer use in LAC displays substantial dispersion, this variability is not especially large relative to other regions such as Asia or Europe. Within LAC, the countries with the highest fertilizer intensity (ranked in descending order) are Costa Rica, Colombia, Trinidad and Tobago, Brazil, and Belize, with application rates close to or above 300 kg/ha—well above those observed in Argentina, Cuba, Haiti, and Bolivia, where fertilizer use remains below 50 kg/ha (Graph A.3.2 in the appendix to this chapter, available in the online edition of RED).

With respect to inputs used for pest and weed control, LAC records significantly higher pesticide use per hectare than other regions. While pesticide use in LAC has followed a clearly increasing and volatile trend over time, it has remained more stable elsewhere, with the exception of Australia and Oceania since 2018. These patterns reflect differences in agricultural intensification strategies, regulatory frameworks, and the adoption of more sustainable practices.

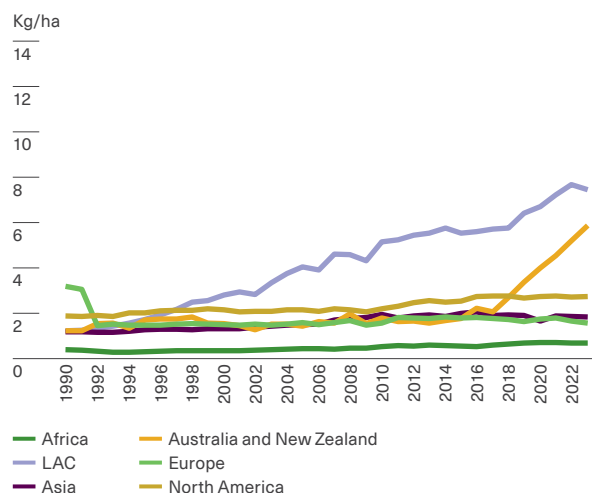
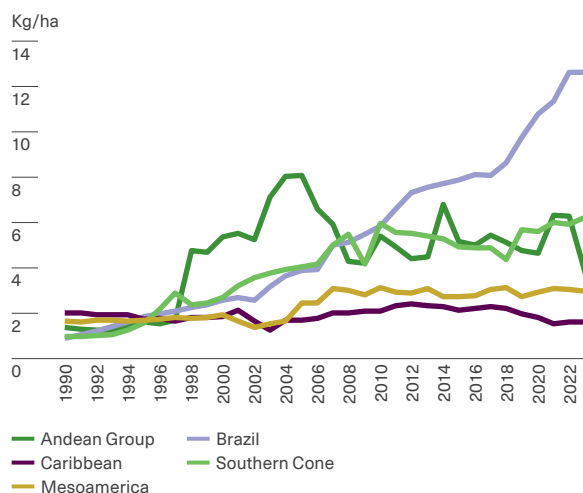


Fertilizer use increased substantially—driven largely by Brazil—while the region stands out for pesticide use that is higher than in other parts of the world

Once again, heterogeneity within the region is striking. In the Caribbean—excluding Cuba and Haiti—pesticide use is intensive, exceeding 20 kg/ha, whereas in the rest of the region, most countries record values below 10 kg/ha. Higher pesticide use in the Caribbean may be partly explained by the region's temperature and humidity conditions, which favor the spread of pests and crop diseases, although it may also point to less efficient agricultural practices (Graph A.3.3 in the appendix to this chapter, available in the online edition of RED).

Graph 3.18

Evolution of pesticide use ,1990-2023

Panel A.
Latin America and the Caribbean compared
with other world regions**Panel B.**
Subregions of Latin America and the Caribbean**Source:** Authors based on data from the FAO (2025h).

One practice that has expanded in recent decades is organic agriculture, which reduces reliance on synthetic pesticides and fertilizers. Although its share in total agricultural production remains

small, it is expected to continue growing over time. Box 3.2 provides further details on organic agriculture in the region.

Box 3.2

Organic agriculture

Organic agriculture is based on production systems that seek to maintain the health of soils, ecosystems, and people by avoiding the use of synthetic inputs. By prioritizing ecological processes, biodiversity, and natural cycles, this approach to land management makes a significant contribution to environmental sustainability.

Globally, organic agriculture has expanded steadily over recent decades. According to FAO land-use data, between 2004 and 2023, the area devoted to organic agriculture increased fivefold, reaching 98.8 million hectares. This expansion was driven largely by Australia, which accounts for 54% of the world's total organic agricultural land.

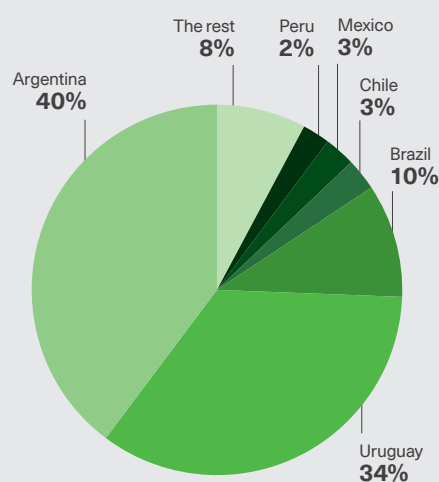
In Latin America and the Caribbean, growth has also been substantial. The area under organic agriculture quadrupled over the same period, reaching 10.3 million hectares—more than 10% of the global total. Within the region, the countries with the largest areas devoted to organic agriculture are Argentina (4.1 million ha), Uruguay (3.6 million ha), and Brazil (1 million ha), which together account for 84% of the regional total (panel A of Graph 1).

Organic agriculture currently accounts for 2.1% of global agricultural land, while in LAC the share is similar, at 2.3%. Uruguay has the highest share of organic agricultural land in the region (25%), followed by Dominica (12%), the Dominican Republic (5%), and Argentina (4%) (panel B of Graph 1).

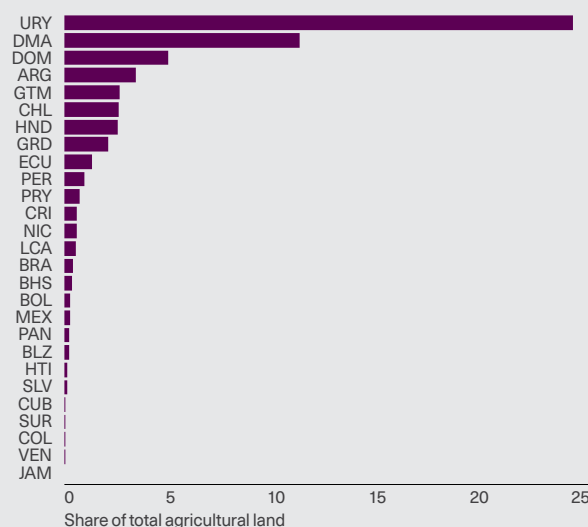
Graph 1

Organic agriculture in Latin America and the Caribbean

Panel A.
Distribution of organic agricultural land
across countries



Panel B.
Share of organic agricultural land
in total agricultural land



Source: Authors based on data from the FAO (2025I).

With respect to land use under organic agriculture in LAC, permanent pastures dominate, accounting for nearly 75% of organically managed agricultural land and located primarily in Argentina, Uruguay, and Brazil (Graph 1). Permanent crops—such as coffee, cocoa, and tropical fruits—represent approximately 11% of organic agricultural land, with the largest areas found, in descending order, in Peru, Mexico, Colombia, the Dominican Republic, and Ecuador. Annual crops account for only about 5% of organic land, led—also in descending order—by Bolivia, Paraguay, Argentina, and Mexico, mainly in the production of cereals, sugarcane, and oilseeds (Willer et al., 2024).

Biotechnology and the use of improved seeds

Biotechnology encompasses a set of techniques and tools that use living organisms or substances derived from them to understand and manipulate genetic structures for various purposes. These include genetic improvement of plants and animals to raise yields; the characterization and conservation of genetic resources for food and agriculture; the diagnosis of plant and animal diseases; vaccine development; and the production of fermented foods (FAO, n. d.a.; 2004).

Modern biotechnology incorporates genetic engineering tools that allow the direct modification of an organism's DNA through the insertion, deletion, or alteration of specific genes in order to confer desired traits, such as pest resistance, herbicide tolerance, or improved nutritional quality.

Box 3.3

Key advances in agricultural biotechnology

Genetic engineering and genetically modified (GM) crops: insertion of genes that confer herbicide tolerance, insect resistance, or enhanced nutritional traits.

Gene editing (CRISPR-Cas^a and others): enables precise modification of DNA without introducing foreign genes, accelerating the development of improved crop varieties or animal breeds.

Marker-assisted selection and genomic selection: application of molecular tools to accelerate plant and animal genetic improvement programs.

Reproductive biotechnology in livestock: advances in artificial insemination, embryo transfer, cloning, and the production of transgenic or genetically edited animals.

Use of microorganisms and bioproducts: development of biofertilizers, biopesticides, inoculants, and probiotics that improve crop and animal nutrition and health.

Molecular diagnostics and next-generation vaccines: rapid disease detection using polymerase chain reaction (PCR) or sequencing techniques, and the development of recombinant or DNA-based vaccines for veterinary use.

Tissue culture and in vitro propagation: production of healthy, virus-free plants with uniform characteristics for rapid multiplication.

Bioinformatics and applied genomics: use of high-throughput sequencing, data analysis, and computational biology to identify genes of interest and understand their function in plants and animals.

Biotechnology applied to sustainability: development of crops resistant to drought, salinity, and heat stress; production of biofuels; and the valorization of agro-industrial residues.

a. CRISPR stands for Clustered Regularly Interspaced Short Palindromic Repeats; Cas proteins are enzymes that cut DNA.

Source: Authors based on the FAO (n. d.a) and the USDA (n. d.a).



Advanced-technology agricultural seeder in Brazil.



The adoption of genetically modified seeds—led by Brazil and Argentina—has played a key role in boosting yields and strengthening the resilience of strategic crops such as soybeans and maize

In agriculture, these techniques are applied to the development of improved seeds that embed genetic innovations aimed at enhancing crop productivity and resilience. Seeds developed through biotechnology—including genetically modified (GM) seeds—result from the application of genetic engineering tools and marker-assisted breeding techniques (see Box 3.3). Their use contributes to higher agricultural productivity,

lower losses, and more efficient use of natural resources (USDA, n. d.a).

Globally, the main GM crops (also referred to as transgenic crops) are soybeans, maize, canola (rapeseed), and cotton, although crop selection varies across regions and countries. For example, insect-resistant cotton is the most commercially significant transgenic crop in Asia and Africa, while in Latin America, herbicide-tolerant soybeans and insect-resistant maize predominate (Halford, 2003).

In Latin America, several countries show high adoption rates of GM seeds, particularly for soybeans, maize, and cotton. Brazil and Argentina stand out as major producers, ranking second and third globally—after the United States—in the production of biotech crops.²³

Digitalization as a technological ally for the agricultural sector

Digitalization in the agricultural sector refers to the adoption of information and communication technologies (ICT) to transform and optimize production practices, resource management, and decision-making. This process encompasses the generation, collection, exchange, aggregation, combination, analysis, access to, and presentation of digital content, as well as the development of new digital services and applications.

The agricultural sector is undergoing a set of transformative trends driven directly by digitalization. These include a growing emphasis on precision agriculture, the application of the Internet of Things (IoT) in farm operations, and the extensive use of big data to enhance both production and business efficiency. These technologies are already being deployed in several countries in the region. In Brazil, the Brazilian Agricultural Research Corporation (Embrapa) is

developing systems based on IoT and artificial intelligence (AI) algorithms to monitor crops and predict agricultural yields. More recently, it has launched research initiatives on the application of quantum computing to agriculture, with potential benefits for climate modeling, early detection of plant diseases, and genomic analysis (Embrapa, 2024). In Argentina, the National Institute of Agricultural Technology (INTA), through its AgTech Program, is advancing innovations such as 3D biomass sensors, monitoring drones, robotic milking systems, and AI applications in agricultural machinery (Ministry of Economy, 2025).

²³ Table A.3.1 in the appendix to this chapter, available in the online edition of RED, presents the main genetically modified crops and their adoption rates by country.

More broadly, digitalization can generate significant productivity and sustainability gains across all stages of the production process—from access to inputs and primary production to storage, logistics, industrial processing, and the distribution and final sale of products. Box 3.4 outlines some of the main digital tools available to the agricultural sector.



Developments such as the Internet of Things and the extensive use of big data are helping boost production and productivity

Box 3.4

Key digital tools for the agricultural sector

- 1. Internet of Things (IoT).** This refers to a network of physical objects connected to the internet that collect, exchange, and analyze data through sensors, software, and other technologies. In the agricultural sector, examples include soil sensors that measure moisture and nutrient levels, weather stations, GPS-enabled collars for livestock, autonomous agricultural robots, as well as mobile phones and computers, among other devices. This connectivity enables the automation of routine processes—such as irrigation and fertilization—and the generation and analysis of large datasets (FAO, 2022b).
- 2. Big data and artificial intelligence (AI).** In agriculture, the growing availability of digital data—from sensors, IoT-equipped machinery, satellite imagery, drones, harvest records, and other sources—makes it possible to train AI algorithms and optimize production decisions. For example, using machine-learning techniques, AI can predict yields based on satellite images, diagnose plant diseases from photographs of leaves, or recommend optimal planting times by combining historical climate and market data.
- 3. Blockchain.** This is a digital data registry organized into sequentially growing sets (blocks) that form a chronological chain, secured through cryptographic links to ensure protection and integrity. This technology enables the secure transaction, storage, and recording of data blocks, ensuring traceability throughout the production process. It also streamlines transactions and secures payments by reducing intermediaries, and facilitates the recording of information—such as the carbon emissions of a plot of land or compliance with organic standards—thus enabling the creation of digital assets.
- 4. Biotechnology and genetics.** These can be considered part of the technological modernization of agriculture, as advances such as gene editing are producing new crop varieties that are more resistant to pests, diseases, and water stress. These innovations complement the broader set of technological solutions needed to address climate change and increase agricultural productivity.

Source: Finkelstein and Odriozola (2025).

At the input acquisition stage, digitalization provides agricultural producers with tools to compare prices and characteristics of essential inputs—such as fertilizers, seeds, and veterinary medicines—through web portals or mobile applications. These digital platforms are often developed by agrifintech companies and frequently integrate credit application options within the same interface. This promotes competition in input markets, increases transparency, and can lead to significant cost reductions for farmers.

The primary production stage is where a wide range of digital tools is deployed to enhance productivity. Platforms such as advanced weather services aim to improve yields by using reliable, up-to-date data processed through AI. Global positioning system (GPS) technologies and geographic information systems (GIS) allow farmers to collect and analyze spatial data to precisely identify optimal planting times and the most suitable locations for crops based on site-specific conditions. A particularly illustrative example of these advances is precision agriculture, which is reshaping farming practices by combining advanced machinery with information technologies. This production approach relies on tools such as GPS, drones, and IoT sensors to monitor key indicators of crop health, soil quality, and water use in real time. The result is more efficient resource management and, ultimately, higher yields.

Sensors and drones enable the collection of precise, real-time information, improving the efficiency of land management (IDB Invest, 2023). For instance, soil sensors measure moisture levels, pH, and nutrient content, allowing for targeted fertilization and irrigation that reduce resource waste and improve overall crop health. Data gathered through these tools also support the monitoring of pests, weeds, and diseases and serve as the basis for AI-driven predictive models. Drones, meanwhile, play a key role in aerial surveillance by providing high-resolution images that allow for the rapid detection of issues such as pest outbreaks or water stress in crops.

The vast volume of data generated by these technologies can be processed using big data analytics tools, which deliver clear and actionable insights to agricultural producers, enabling more informed decision-making. For example, advanced weather forecasts support timely operational decisions, while yield prediction models, by combining historical data with current conditions, help fine-tune practices to maximize output.



New digital tools enable greater collection and analysis of agricultural data, supporting more informed decision-making

Complementing these developments are automation and agricultural robotics. The use of automated machinery—such as autonomous tractors and harvesters equipped with AI—reduces labor costs and increases efficiency by enabling highly precise operations over longer periods without direct human intervention. Agricultural robots can automate a wide range of activities, including planting, spraying, plant counting, and fruit sorting, among others.

Countries such as Argentina and Brazil have positioned themselves as leaders in the adoption and development of these technologies. In Argentina, precision agriculture has been instrumental in increasing productivity and reducing costs by enabling georeferenced resource management (AgroSpray, 2020). In Mexico, the export-oriented horticultural sector—particularly in the state of Sonora—has adopted digital agricultural technologies such as drones, agroclimatic and soil moisture monitoring systems, and GPS-enabled “smart” machinery. These innovations have improved production efficiency and have been a key factor in the region’s recognition as a benchmark for agricultural competitiveness (Hernández-Pérez, 2019).

Box 3.5

Initiatives to promote agricultural digitalization among women

Rural women continue to face particularly disadvantaged conditions with respect to access to and use of digital and adaptive technologies. Several recent initiatives seek to address this gap. Since 2024, FAO's Programme to Accelerate the Empowerment of Rural Women and Environmental Sustainability has promoted the use of digital technologies and productive innovations in Jamaica, Honduras, and the Dominican Republic, with the aim of improving agricultural production and strengthening the integration of rural women into agricultural value chains (FAO, 2024c).

The FAO–China Cooperation Programme on Digital Transformation and Innovation in Agriculture provides technical and financial support for digital projects in twelve countries in Latin America and the Caribbean (Argentina, Barbados, Chile, Costa Rica, Guyana, Jamaica, Mexico, Panama, Suriname, Trinidad and Tobago, and Uruguay). Its objective is to reduce the digital gaps that became evident during the COVID-19 pandemic (SELA, 2024).

In Chile, under the United Nations' Connected Communities project, rural women participated in training programs on digital tools aimed at facilitating access to government services, strengthening their digital literacy and autonomy in managing administrative procedures and accessing public benefits (United Nations Chile, 2024).

Source: Barbara Auricchio.

Digitalization also delivers substantial gains in storage, logistics, and agroindustrial processing. Notable applications include the use of IoT technologies in silos, warehouses, and transport vehicles to monitor variables such as temperature and humidity, ensuring optimal transport conditions. Digital technologies also support the development of electronic inventories, improving management, transparency, and control of stored products. Digital logistics platforms connect agricultural producers with transport services, streamlining distribution and reducing costs. In addition, smart packaging offers opportunities to enhance food safety and quality by monitoring freshness, temperature, and expiration dates. A concrete example is the use of QR codes, which provide end consumers with detailed information on harvest dates and locations, production practices, and organic certifications.

In the distribution and sales phase, online trading platforms expand producers' market reach and help reduce the number of intermediaries. Digital

marketplaces allow agricultural producers to sell directly to consumers, enabling them to retain a larger share of profits. These platforms are complemented by digital payment and delivery services that help consolidate online sales. Mobile applications providing real-time market prices further empower producers to make better selling decisions. The adoption of digital payments also brings additional benefits by creating transaction records that can facilitate access to credit, generating valuable information for potential lenders.

All of these technologies converge toward a broader goal: sustainability and the reduction of environmental impacts. Improved management of resources such as water and nutrients lowers their use, while data-driven agricultural practices make it possible to adopt more sustainable methods that protect soil health and biodiversity. Taken together, digitalization promotes sustainable agricultural practices, improves efficiency, and supports economic growth in the sector, ultimately

contributing to food security and resilience to challenges such as climate change.

Despite this substantial potential, the adoption of digital solutions faces significant barriers, particularly in rural areas. Key constraints include limited basic infrastructure—such as electricity and connectivity—a workforce that is not always prepared to adopt and use digital tools, difficulties in accessing technology and information, and limited access to financing.

It is also important to recognize that not all technologies are universally applicable. In many cases, technologies must be adapted to local conditions, or entirely new solutions must be developed to respond to the specific needs of a given territory. Achieving this requires investment in research and development (R&D), driven by public, private, or public–private initiatives, to foster the development of relevant, accessible technologies.

Climate change: Challenges and opportunities for the sector

Ortiz-Bobea et al. (2021) estimate that, since 1961, climate change has reduced agricultural total factor productivity (TFP) by 21%, with more severe impacts in Latin America and Africa. According to calculations by Deng et al. (2023), each one-degree Celsius increase in global warming between 2000 and 2020 led to declines in global yields of maize (–3.4%), wheat (–2.4%), rice (–0.3%), and soybeans (–5.0%), although with substantial regional variation.

Rising average temperatures are expected to reduce agricultural productivity in regions that are already warm, while increasing productive potential in high-latitude areas closer to the poles, where historically low temperatures have constrained agricultural activity. In warm regions such as northern Mexico, Aragón et al. (2018) project that, under future warming scenarios, maize yields could decline by between 7% and 20%. By contrast, in temperate-cold areas such as Argentina's Pampas region, a moderate increase in temperature and precipitation is expected to raise soybean productivity by 5% to 10%, as a result of a longer growing season (FAO, 2015a).

Changes in temperature, precipitation, and humidity may also alter soil conditions and the suitability of different crops across regions. Countries' ability to

adjust and reallocate agricultural production across territories—particularly by shifting production away from areas that may lose productivity toward those that may gain from climate change—will be critical in determining whether the effects of this phenomenon can be mitigated or even turned to advantage.

To assess the potential impact of climate change on agricultural production, Adamopoulos (2025) analyzes the effects of a climate change scenario on potential yields and incorporates into his analysis a counterfactual involving spatial reallocation and crop mix adjustment.²⁴ Table 3.1 summarizes the results.²⁵ Focusing first on the effects of climate change without spatial reallocation, two patterns emerge. In general, countries in the region—many of which are characterized by warm climates—are expected to experience losses in potential yields due to climate change. For the region as a whole, these losses are estimated at around 22%. However, the effects are highly heterogeneous, with countries such as Antigua and Barbuda facing substantial losses (potentially up to 65%), while others, such as Jamaica or Canada, could experience increases in potential yields (of around 40%).

24 The climate change model is GFLD-ESM2M (Geophysical Fluid Dynamics Laboratory-Earth System Model 2M).

25 Table A.3.2 in the appendix to this chapter, available in the online edition of RED, provides detailed country-level results.

The second experiment allows for spatial reallocation and changes in crop composition. Spatial reallocation alone could generate gains of 30% relative to the scenario without reallocation, nearly offsetting the aggregate negative effects of climate change for LAC (1,469 versus 1,477). Allowing for changes in crop composition would generate an additional gain of 70% relative to the scenario with reallocation. Once again, these gains are unevenly distributed. In the United States, for example, gains from both channels are similar, at around 20% (19% from reallocation and 23% from crop recomposition). In Antigua and Barbuda, by contrast, spatial reallocation contributes little to improving yields, while changes in crop composition raise yields above current potential levels.

●●

Spatial reallocation of production and changes in crop composition can help counteract the negative effects of climate change

Overall, climate change is likely to have adverse effects on potential agricultural yields in the region. However, spatial reallocation and changes in crop composition could help attenuate—or even reverse—these effects. These findings highlight the central role of governments in supporting the transformation of agricultural production, both in its geographic distribution and in its crop mix, to address the challenges posed by climate change.

Table 3.1
Effects of climate change and spatial reallocation

	Potential yield						
	Current (1)	Under climate change (2)	Ratio (2)/(1)	With spatial reallocation of crops (3)	Ratio (3)/(2)	With spatial reallocation and changes in crop composition (4)	Ratio (4)/(3)
LAC	1,477	1,140	0.8	1,469	1.3	2,493	1.7
Antigua and Barbuda	2,879	1,285	0.4	1,310	1.0	3,454	2.6
Canada	648	829	1.3	948	1.1	1,618	1.7
Jamaica	1,242	1,763	1.4	1,924	1.1	2,364	1.2
United States	1,457	1,183	0.8	1,410	1.2	1,728	1.2

Note: Yields are measured as the value of production at international prices per hectare.
Source: Authors based on Adamopoulos (2025).

Policies to improve agricultural productivity

Agricultural productivity growth in LAC has been similar—or even higher than—levels observed in high-income countries where the sector plays an important role, such as the United States. However, this growth has not been sufficient to close the deep productivity gap the region continues to face—a gap with multiple dimensions. Aside from the clear, though uneven, shortfalls in capital per worker and low land endowments per worker, the evidence is clear: productivity differences are explained to a large extent by the intensity of input use. While the lag in pure efficiency is a critical factor—accounting for more than half of the gap in

value added per worker—the gap widens further once the low use of intermediate inputs is taken into account.

The policy agenda to boost agricultural productivity in the region is therefore multifaceted. It includes public investment in public goods (such as updated cadastre systems and road infrastructure), private investment in advanced technologies, and improved access to financial and insurance services for producers. The following sections discuss several of these policy dimensions.

Land ownership and cadastre

Land is not only the main factor of production in agriculture; it is also a core asset whose legal status shapes investment incentives, access to finance, efficient land use, and social stability in rural areas. In LAC, structural problems related to land tenure and land administration represent one of the main constraints on productivity. This section outlines policies aimed at strengthening tenure security and modernizing cadastre systems as essential pillars of agricultural development.

substantial increases in investment and agricultural productivity. In Peru, for example, the Programa Especial de Titulación de Tierras (PETT), launched in 1993, had positive effects on land-related investment, land market values, and the reallocation of household labor toward agricultural activities. In Nicaragua, parcel regularization significantly increased the likelihood that farmers would invest in on-farm improvements.²⁶

Land tenure security

Policies to formalize property rights—primarily through large-scale titling and tenure regularization programs—are critical for agricultural and broader rural development. Their objective is to legally recognize and register the property rights of those who occupy and work the land, providing the legal certainty needed to catalyze investment and agricultural development. Evidence from the region shows that land certification or titling can lead to

The experience of Mexico's PROCEDE program, which converted *ejido* (communal land) use rights into certified property rights, shows that separating tenure from use can improve efficiency. Certification facilitated migration, promoted modest land consolidation, and improved household welfare without reducing cultivated area. These outcomes suggest that secure and transferable rights enable a more efficient allocation of land, labor, and capital (De Janvry et al., 2015).

26 For a more detailed and systematic review of these land-regularization cases, see López et al. (2017).

For these policies to be effective, they must be backed by strong political and financial commitment from the government. They must also be designed to reflect the diverse economic, social, and cultural realities of beneficiaries, with particular attention to securing the land rights of Indigenous peoples, a historically marginalized group.



Formalization and titling of land ownership are key to encouraging long-term investment, facilitating access to credit, and improving productive efficiency

Modernization of land administration and cadastre systems

Modernizing land administration and cadastre systems is a cornerstone of rural development in LAC. The region faces the dual challenge of having one of the most unequal land distributions in the world and some of the lowest levels of land registration and cadastre coverage, with irregular tenure exceeding 50% in some countries. Addressing this situation requires a transformation of land administration systems (LAS), guided by comprehensive policies and supported by technological adoption.

A first priority is investment in technological innovation for LAS. Modern, integrated, and secure systems are associated with greater access to credit, lower income inequality, reduced corruption, and a more favorable investment climate. Modernization is particularly critical in a region where, according to a survey covering 16 countries, only one—Uruguay—has a complete cadastre.

Key elements of this modernization include digitizing records and collecting data through global navigation satellite systems (GNSS) and geographic information systems (GIS). These technologies are especially important in rural areas, where they help unlock economic capital immobilized in land without legal security. A major challenge in the region is the traditional separation between land registries and cadastre institutions; promoting online services and institutional and electronic interoperability across government agencies is therefore essential. The creation of a unified information system (UIS), based on international standards such as the Land Administration Domain Model (LADM), can help avoid fragmented efforts and inefficient use of resources. Cadastre modernization can also generate substantial fiscal gains. In Colombia, for example, cities that updated their cadastres between 2014 and 2018 increased property tax revenues by 60%—more than twice the increase observed in cities that did not (Cerrato et al., 2022).

Second, investment should prioritize the development of modern, multipurpose cadastres conceived as comprehensive inventories of real estate wealth that serve fiscal, legal, planning, and development purposes. The transition toward multipurpose cadastres—still progressing slowly in the region—requires coordinated policies and actions. These include legal reforms to establish a unified framework for urban and rural cadastres and the decentralization of cadastre management. Delegating updating and maintenance to municipalities or “associated centers,” which have deeper knowledge of local territories, is a key step, provided their technical and operational capacity is strengthened. Building spatial data infrastructures (SDIs) is essential to ensure interoperability among cadastre, registry, planning, and other institutions. Innovative methodologies—such as fit-for-purpose approaches and social mapping—are also needed to expand cadastre coverage, particularly in rural areas where coverage remains limited. To strengthen legal security, specialized land courts should be established and alternative dispute resolution mechanisms reinforced, making them faster and less costly (FAO, 2022b).



Investing in technological innovation for cadastre systems—making them multipurpose and interoperable—can improve fiscal revenues, planning capacity, and access to credit

Finally, cadastre investment should prioritize historically marginalized rural areas and

environmentally critical zones for climate change mitigation and adaptation. These include water basins, Indigenous forests and tribal lands, and national protected area systems, which paradoxically are often among the least regularized territories with the most outdated tenure information. To prevent phenomena such as “digital land grabbing,” these processes must be transparent, participatory, and grounded in a rights-based approach.

Access to financial instruments

Access to financial instruments is critical for the agricultural sector. This is true both on the credit side, which enables larger investments and longer maturities, and on the insurance side, given that agricultural activity is exposed to a wide range of risks—primarily, though not exclusively, climatic.

Compared with Canada and Australia—two developed countries with highly dynamic agricultural sectors—LAC has, on average, a level of agricultural credit relative to GDP that is broadly in line with Canada’s, but far below Australia’s. Within the region, however, realities are highly heterogeneous. In Belize and Bolivia, for example, agricultural credit represents about 4% and 8% of GDP, respectively, while in most countries this share is close to 0%, particularly in Caribbean island economies.

Examining the evolution of this indicator between 2003 and 2023 shows that in a small group of countries—including Bolivia, Nicaragua, Panama, and Uruguay—agricultural credit as a share of GDP increased, whereas it declined in most others. Several Caribbean islands stand out once again, such as Saint Lucia, Barbados, Dominica, and Saint Vincent and the Grenadines, where the share fell from around 1% in 2003 to close to 0% in 2023.

Another way to assess the relevance of agricultural credit is by examining its share of total credit. On this measure, LAC again posts values well below those observed in Canada and Australia. This low share likely reflects the difficulties agricultural producers in the region face in accessing credit. As before, heterogeneity across countries is substantial. In some countries with large agricultural sectors, such as Argentina and Uruguay, agricultural credit accounts for roughly 14% of total credit, levels that even exceed those of Australia and Canada. In contrast, in many Caribbean island economies, this share is virtually zero.

When designing policies to expand access to financial services in the agricultural sector, it is useful to distinguish among different target groups. On the one hand, small producers make limited or no use of financial instruments; for them, policies should focus on financial inclusion, aimed at expanding access to and use of services. On the other hand, medium and large producers—or technologically advanced small producers—are likely already frequent users of financial instruments; for these groups, the focus should be on expanding or improving existing products and reducing their costs.

Financial inclusion and access to credit

In recent years, there has been significant progress in financial inclusion. Microfinance—originally developed in the 1980s as a tool to combat poverty by providing small loans to small-scale producers—has been widely used as a financial inclusion instrument in developing regions. However, despite some successes, the results of microfinance initiatives have often fallen short of expectations. Banerjee et al. (2015) show that the impact on credit demand was smaller than anticipated, with limited or no effects on beneficiaries' profits. Moreover, outcomes have been highly heterogeneous, underscoring the critical importance of beneficiary selection—an aspect frequently overlooked in credit policies. Identifying producers with the greatest potential for success is inherently difficult. In addition, extending subsidized credit without rigorous targeting criteria can be costly and may lead to resource misallocation, sustaining low-productivity producers rather than fostering the expansion of more dynamic ones.

In response to these limitations, recent years have seen the emergence of key innovations in the microfinance sector aimed at tailoring products more closely to clients' realities. On the one hand, contractual terms have been adjusted through the inclusion of grace periods that allow for greater investment, more flexible repayment schedules, performance-based incentives that adjust conditions according to early outcomes, and the acceptance of assets as collateral. On the other hand, renewed emphasis has been placed on improving beneficiary selection processes. These adaptations are particularly relevant for the agricultural sector, which has distinctive characteristics: a production cycle with a longer lag between investment and sales, and high exposure to climate risk—an inherently random factor, but one that is easily verifiable by lenders. Designing credit lines that account for these features is therefore essential if microfinance instruments are to be truly effective in rural areas.

Governments have a broad range of instruments at their disposal to promote access to credit for agricultural producers. These include the

promotion of special credit lines and guarantee funds for both family and commercial agriculture. In addition, governments can implement subsidized interest-rate policies to reduce the financial cost of borrowing, a strategy that is central to Brazil's Program for Strengthening Family Farming (PRONAF). Another approach involves providing direct incentives for capitalization, whereby the State co-finances part of the investment in technology or infrastructure—as in the case of Colombia's Fund for the Financing of the Agricultural Sector (Finagro)—thereby reducing producers' indebtedness. Equally important is linking credit to technical assistance and rural extension programs, ensuring that financial resources are complemented by the knowledge needed to maximize their impact, as implemented by Mexico's Trust Funds for Rural Development (FIRA).

Access to credit can be an even greater constraint for women producers with informal incomes and without traditional forms of collateral. In many cases, the lack of formal land ownership prevents them from meeting standard banking requirements. To address this challenge, it is essential to develop instruments that accept alternative forms of collateral, such as group guarantees, savings histories, or community recognition. Credit products specifically targeted at rural women—such as those developed by Agrobanco in Peru, Fundación de la Mujer in Colombia, and Fundación Microfinanzas BBVA in five Latin American countries (all operating under the name Agromujer)—demonstrate that adapting financial offerings can strengthen both women's economic autonomy and food security.

Finally, promoting digitalization is a key priority, as it serves as a powerful enabler for overcoming physical barriers in rural areas, reducing costs and fees, and expanding the range of financial instruments available to producers. In this context, alternative mechanisms are being developed to build credit scores for individuals without a formal banking history. For example, the IDB and the financial institution Confianza conducted a pilot project in Peru using psychometric tools to assess the credit risk of micro, small, and medium-sized enterprises without credit histories. The results showed that these tools made it possible



Greenhouse worker in Mexico.

to extend credit to entrepreneurs without prior credit records without deteriorating portfolio performance (Klinger et al., 2013). Although this pilot was not applied specifically to rural producers, it represents an important precedent in financial inclusion innovation in the region and has been adopted elsewhere. In Africa, for instance, AI-based credit-scoring models for smallholder farmers in Kenya have been implemented using alternative data sources such as crop yields, sales, and payment behavior (Mengede, 2025).



Digitalization can help improve access to financial instruments by reducing costs and fees and expanding the range of financial services available

Insurance

Agricultural activity is inherently risky—a condition exacerbated by the growing uncertainty associated with climate change, which intensifies both production and market risks. Faced with this, producers, especially lower-income family farmers, often resort to costly coping strategies: inefficiently diversifying production, depleting savings, or even being forced into migration or child labor. These responses not only undermine their well-being but also constrain their productive potential.

Against this backdrop, agricultural insurance emerges as a key financial instrument. In addition to stabilizing farm income in the face of adverse events, agricultural insurance can also improve access to other financial instruments—particularly credit—by substantially reducing default risk. Box 3.6 briefly describes the main types of agricultural insurance.

Box 3.6 Agricultural insurance

Within agricultural insurance, four main types of products can be identified:

- Single-peril insurance covers losses from a specific event, such as hail.
- Multi-peril insurance, the most commonly used type in the region, covers a range of natural and biological risks.
- Revenue insurance guarantees producers a certain income level regardless of the cause of the income loss.
- Parametric or index insurance covers production losses based on variables that are highly correlated with output and easy to verify, such as rainfall levels or extreme temperatures.

As expected, broader coverage and a higher likelihood of the insured event are associated with higher insurance premiums.

For small producers, these benefits can translate into a virtuous cycle of growth. Insurance provides the confidence needed to innovate, enabling the adoption of more profitable—albeit riskier—crops or technologies. By spreading risk and improving creditworthiness, insurance strengthens investment capacity, an effect that can be transformative. Indeed, studies such as Karlan et al. (2014) show that insurance uptake can increase investment and productivity on small farms even more effectively than direct credit lines. Finally, by easing financial stress, insurance also helps producers make better decisions (Mullainathan and Shafir, 2013).

Promoting a dynamic and accessible agricultural insurance market is therefore not only a social protection measure; it is also a strategic policy tool to boost productivity, innovation, and resilience in the agricultural sector.

It is striking, then, that agricultural insurance coverage remains low. According to Montes et al. (2020), 81% of small farmers (with less than 2 ha) in lower-income countries (excluding China) lacked agricultural insurance in 2019; in LAC, the figure was 67%. Kapsambelis et al. (2019) attribute this low coverage to both demand- and supply-side constraints. On the demand side, these include inadequate risk perception; premiums that are too costly for low-income households; limited financial literacy, which hampers understanding of insurance products; and the perception that insurance is not a worthwhile investment. On the supply side, constraints include the inherently high risk of agricultural activity and governments' tendency to promote market development through subsidies and disaster-relief funds, which can affect the design and pricing of insurance programs; the need for increasingly large investments to offer high-quality products; and the costs of education campaigns required for potential users to understand them. These challenges are further compounded by the need for low-cost sales and claims-verification channels, as well as by the information asymmetries inherent in these instruments.

Governments can play an active role in addressing several of these constraints. On the one hand, they can provide the information needed to measure, assess, and monitor risks, either by developing

agencies to collect such data or by making information already gathered by public entities more accessible. On the other hand, they can promote the development of agricultural insurance markets by designing appropriate regulatory and supervisory frameworks; acting as reinsurers or providers of last-resort support in the face of catastrophic events beyond the capacity of private insurers; and offering technical assistance and training to private insurance providers.

Drawing on a review of multiple initiatives in the region, the International Fund for Agricultural Development (IFAD) (Montes et al., 2020) identifies several key lessons for strengthening agricultural insurance. A central one relates to product design: insurance policies must be affordable, financially sustainable, and tailored to the specific needs of agricultural producers. In this regard, parametric or index-based insurance schemes emerge as a particularly promising option for small producers, as payouts are triggered by easily verifiable variables—such as rainfall levels—thereby eliminating the need for individual loss assessments.



Agricultural insurance policies must be affordable, sustainable, and tailored to farmers' needs

More broadly, market development requires a robust ecosystem based on collaboration among insurers, reinsurers, regulators, and technology firms, where the presence of a coordinating entity can be critical to organizing supply. Fostering innovation and competition is also essential, including through the use of digital technologies to reduce costs and regulatory sandboxes to test new models. Above all, a mission-oriented approach should prevail—one that prioritizes the well-being of agricultural producers while maintaining financial sustainability. When these conditions are met, the impact extends beyond the insurance policy itself: insured producers face a lower risk of default, improving their access to other financial instruments, such as credit.

Agricultural infrastructure

The development and strengthening of robust agricultural infrastructure should be a core policy priority for the agricultural sector. Such strategic investment is essential to enhance competitiveness, reduce post-harvest losses, and improve farmers' quality of life. A comprehensive agricultural policy must go beyond direct support to production and encompass the entire value chain. In this regard, priority areas for action include road connectivity and telecommunications, irrigation infrastructure, storage facilities, and cold-chain logistics.

An adequate road network helps reduce the costs and time associated with transporting inputs and products, facilitating linkages between rural areas, consumption centers, and ports. Expanding telecommunications and internet coverage in rural areas also enables access to information on weather conditions, market prices, and farming technologies, as well as the remote management of operations, thereby improving resource efficiency.

Irrigation infrastructure is likewise critical to reducing risks associated with climate variability and water scarcity. Investment in drip irrigation, sprinkler systems, and other precision technologies can contribute to more stable and efficient production while promoting the sustainable use of water resources. This, in turn, requires the availability of off-farm irrigation infrastructure to ensure reliable access to water supplies.

Finally, the establishment of adequate storage facilities enables the handling and temporary storage of primary products, helping to reduce post-harvest losses. Strengthening cold-chain infrastructure—through refrigeration facilities at the farm level, in storage centers, and during transport—is also essential to preserve quality and extend the shelf life of fruits, vegetables, and other perishable products, facilitating their access to a wider range of markets.

Innovation and digitalization of agriculture

To catalyze a deep and sustainable transformation of the agricultural sector, it is essential to develop and coordinate public policies that promote strategic investment and the inclusive adoption of technology. The success of these policies rests on four interconnected pillars: strengthening human capital, fostering local innovation, creating accessible financing mechanisms, and improving digital connectivity infrastructure. To close the region's technological gap and unlock its full potential, these policies must explicitly include small and medium-sized producers, who are central to rural development.

The first pillar is strengthening human capital, beginning with digital literacy. This strategy requires a dual approach. On the one hand, digital skills must be formally and systematically integrated into rural education and training programs to prepare new generations. On the other hand, with more immediate impact, agricultural extension services

must be modernized. This entails complementing traditional methods with digital tools, such as the dissemination of key information via SMS and hands-on training in the use of specific technologies. Modernized extension services help democratize access to knowledge, enabling small producers to make informed decisions and reduce gaps that constrain their development. The creation of online learning platforms and agricultural forums can further strengthen human capital by fostering the exchange of best practices and collaborative learning.



Local innovation and dynamic agritech ecosystems enable the development of technologies better suited to the region's needs

Box 3.7

The Embrapa case in Brazil

Part of the economic literature argues that technological advances and innovation should take place in high-income and frontier countries, where returns on such investments are higher, while other countries should focus on adopting and adapting frontier technologies to local conditions. However, several studies have warned that these adaptation strategies may have limited effects, particularly when innovations are not easily transferable or well-suited to local contexts. Agricultural production—where climatic, geological, and other conditions play a decisive role in adaptation and yields—is perhaps the clearest example of this challenge.

In 1973, Brazil established the Brazilian Agricultural Research Corporation (Embrapa) to “promote, stimulate, coordinate, and carry out research activities aimed at generating knowledge and technology for the development of the country’s agricultural sector” (Law No. 5,851 of December 7, 1972). Embrapa researchers achieved major breakthroughs in agricultural production, including the development of soil management techniques adapted to the acidic soils of Brazil’s central region; the identification of genetic traits that made crops resistant to local pests; and the creation of hundreds of new crop varieties, including the first soybean variety suitable for tropical climates. These advances enabled Brazil to transition from a recipient of food aid to one of the world’s leading food exporters.

In a recent study, Akerman et al. (2025) analyzed the impact of Embrapa on local agricultural production and found that it increased productivity in the sector by 110% and achieved a benefit–cost ratio of 17. This effect is explained primarily by the geographic dissemination of research centers across the country, which enabled the development of technologies better tailored to specific local contexts. These findings provide strong evidence that public R&D can help developing countries escape the technological mismatch trap.

Source: Based on the article written by Akerman et al. (2025).

With more capable producers, the second pillar is the promotion of local innovation to develop relevant, context-specific technological solutions. This requires supporting a dynamic agritech ecosystem that generates advances—digital, biotechnological, and genetic—designed by and for the region. Such an ecosystem can be fostered through the financing of incubation and acceleration programs, the organization of open innovation challenges to address sectoral needs, and the dissemination of success stories that inspire new entrepreneurs. In this process, universities and local research centers must be positioned as key drivers of R&D. The articulation of public–private partnerships, with governments acting as catalysts, is essential to enable startups, cooperatives, and research institutes to co-develop technologies

alongside agricultural producers, ensuring their relevance and adoption.

The third pillar is financing, as technology and training are insufficient without access to capital. It is imperative to design inclusive financial instruments tailored to the digitalization of agriculture. These solutions include targeted credit lines with subsidized interest rates and repayment terms aligned with investment returns; guarantee funds that back small producers in their dealings with commercial banks; and the use of agrifintech platforms to channel resources in an agile and flexible manner. In addition, promoting associative models—such as cooperatives—allows producers to share the costs of acquiring or renting technology, thereby democratizing access to innovation. Ultimately, providing appropriate

financing to support the modernization of small producers is key to improving regional productivity and reducing the deep socioeconomic inequalities that persist in rural areas.

Finally, improving digital connectivity in rural areas requires a combination of investment, public policies that ensure affordable and high-quality

service, and the coordination of public–private efforts to expand the necessary infrastructure. Access to electricity and reliable internet connectivity are indispensable conditions for the digital transformation of the sector. The policies and strategies needed to close these infrastructure gaps are discussed in detail in Chapter 8 of this report.

Trade policy

The region's low level of trade openness is reflected in a relatively modest volume of international trade given the size of its economies, as well as in insufficient regional integration. To promote greater trade openness, countries in the region need to reduce or remove tariff and non-tariff barriers, while taking care not to dismantle sanitary and phytosanitary measures that protect human and animal health in LAC. For example, Mercosur countries, which maintain relatively high tariffs, should consider reducing them gradually.

Among non-tariff measures, improvements in logistics systems and the simplification of customs procedures would have a direct impact on trade by reducing restrictions and trade costs. Finally, one of the region's major shortcomings is the limited progress in regional integration. Addressing this challenge will also require improvements in transport infrastructure—particularly roads (Álvarez et al., 2025).

Mechanization

In LAC, although agricultural mechanization has traditionally been promoted through credit and tax exemptions, a growing trend is the provision of machinery services (FAO, 2022b). Under this model, producers rent equipment through short-term contracts, which may include technical advice and other complementary services. This approach is particularly beneficial for small agricultural producers, as it provides access to modern technology at an affordable cost while relieving them of the financial burden associated with purchasing and maintaining machinery—an investment that is often not viable (FAO, 2022b; Van Loon et al., 2020).

The success and expansion of this model—of which Argentina is a clear example (Elverdin et al., 2018)—depend critically on government support. To this end, the public sector must move beyond traditional incentives and offer a comprehensive support package that directly fosters the supply of these services, including tailored financing, rural infrastructure, and specialized technical assistance. This creates a synergy in which the private sector supplies the machinery, while the public sector acts as a facilitator, ensuring the public goods and enabling conditions needed for the mechanization services market to thrive and benefit small and medium-sized farmers.

Box 3.8

CAF's Strategy for agricultural prosperity

As the green development bank of Latin America and the Caribbean, CAF promotes the transformation of the agricultural sector toward a productive, resilient, and sustainable model.

Between 2014 and 2024, this strategy was implemented through the following core pillars:

- Technology and knowledge transfer, through agricultural extension, biotechnology, and sustainable practices, to boost productivity and climate adaptation.
- Enabling infrastructure, promoting irrigation and the development of connectivity, digitalization, and logistics infrastructure to improve efficiency and market access.
- Sustainable financing, through credit and capital lines to support the adoption of low-carbon and climate adaptation practices and technologies.
- Institutional strengthening, providing technical assistance and cooperation to support public policy formulation and the integrated management of natural resources.

Between 2014 and 2024, this strategy involved investments totaling USD 1.81 billion in lending operations, equity investments, and technical cooperation, complemented by the administration of USD 140 million from the Global Environment Facility and the Green Climate Fund for projects in the agribusiness sector.

This support was channeled through 22 sovereign lending operations, three equity investment operations, and 31 technical cooperation initiatives, directly benefiting 16 countries in the region and helping foster a more productive, sustainable, and inclusive agricultural sector.

Source: Authors based on Maris (2025).



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