ORBITAS
A Climate Advisers Initiative

# Brazil's Soy Sector Amidst Climate Transitions

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## About ORBITAS

This report was produced by Orbitas, a Climate Advisers initiative. Orbitas strives to be a leading source of reliable and actionable analysis on climate transition risks in the agricultural, forest and land economy. Climate Advisers, a B Corporation, works to strengthen climate action in the United States and around the world through research, analysis, public policy advocacy and communications strategies. We develop and promote sensible, high-impact initiatives that improve lives, enhance international security and strengthen communities.

> Further information is available at **climateadvisers.org** and **orbitas.finance**.

REPORT

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# Executive Summary

The Brazilian soy sector will face challenges in a transitioning world. By 2050, government, consumer and private sector responses to climate change, which we term 'climate transitions,' could drive a more than 15 percent decrease in soy pricing, putting a large proportion of today's soy farmers at an over 60 percent risk of financial losses. Profitability shortfalls can be minimized by reducing production costs, land rent payments and greenhouse gas (GHG) emissions costs. Moreover, the opportunities provided by climate transitions are immense, especially given the diversified markets for soy products. Soy producers that invest in sustainable technology improvements, land ownership, reductions in emission intensity and diversified revenue streams from the bioeconomy could benefit substantially from climate transitions. A projected 88 percent increase in agricultural capital investment could unlock yield increases of at least 14 percent by 2050, improving land use efficiency across the Brazilian soy sector. Furthermore, despite a reduction in demand for ruminant meat feedstock, soy's role as a significant contributor to the global plant protein supply, the plant-based oil supply and the biofuel supply could allow producers to capitalize on a more than 14 percent increase in projected global soy demand.

By 2050, the probability of financial loss from economic shocks common under climate transitions could surpass 60 percent across a significant proportion of Brazilian soy producers at current operating margins.

Brazil's soy sector is undergoing profound changes driven by numerous climate-related transitions, including (i) stronger climate goals, policies, trade restraints and legal fines, (ii) growing links between company reputation and environmental performance, (iii) climate technology driven innovation and competition, and (iv) new market dynamics relating to climate change, including consumer demand shifts and emerging market segments. These forces shaping the Brazilian soy sector represent responses to the adverse physical impacts of climate change (such as extreme weather and changes in precipitation patterns) that are already acutely felt by Brazilian producers today and are rapidly accelerating. The interplay of these forces has the potential to transform Brazilian soy production and initiate a race for production efficiency and sustainable management practices.

Even if climate action drives transitions aligned with limiting global warming to 2ºC above pre-industrialized levels rather than the 1.5ºC targeted under the 2015 Paris Agreement, the Brazilian soy sector still faces enormous risks.[a] Under our least ambitious 2ºC-aligned climate transition pathway, soy producer prices would decrease 15 percent by 2050 compared to 2020, as yield improvements reduce production costs and increase efficiency, making it difficult for low-efficiency producers to compete. Meanwhile, competition for land would rise significantly, driven by policies that target deforestation, markets that reward landowners for conserving and restoring natural habitats and demand for plant-based proteins and oils. These changes would result in 11 percent less land available for crops and higher land prices and production costs. Changing consumer preferences around ruminant meat consumption would also decrease the demand for soy as a feedstock significantly, leading to a 3 percent decrease in demand in domestic Brazilian markets and driving a shift toward export markets that are increasingly prioritizing deforestation-free policies.[b]

Climate transition impacts are most material for the least-efficient producers, those with the lowest level of technology adoption and furthest from critical supply chain infrastructure, including demand centers, processing facilities, port facilities and extensive road networks. These producers risk financial losses as early as 2030 and could face losses of over USD 617 per hectare by 2050 if they do not adapt to climate transi-

[a] The Forecast Policy Scenario, aligned with the Principles for Responsible Investment's Inevitable Policy Response Forecast Policy scenario, represents a modest, highly plausible and impactful reference scenario to clearly illustrate the scale of potential impacts that climate transitions will have on the Brazilian soy sector. This scenario is aligned with the actions needed to limit warming to 2ºC over pre-industrialized levels. Market leaders, however, should prepare for the ambitious climate transitions expected in a world that acts to restrict warming to 1.5ºC above pre-industrial levels.

[b] Note that total livestock demand would increase by 19 percent globally over the same period, despite downward pressure in ruminant meat demand.

A projected 88 percent increase in agricultural investment ... would drive the average yield per hectare for soy farmers up by 14 percent between 2020 and 2050.

tions.[c] However, a much broader segment of the Brazilian soy sector could face financial losses as climate transitions intensify. By 2050, the probability of financial loss from economic shocks common under climate transitions could surpass 60 percent across a significant proportion of Brazilian soy producers at current operating margins, making the entire sector vulnerable.

Mitigating risks from climate transitions will require significant and proactive collaboration among producers, investors, policymakers and mid- and downstream value chain stakeholders. Investments made today to enhance the efficiency of soy production, rather than relying on expanding land usage, will be the key differentiator for market competitiveness in 2050. To remain profitable, most soy producers will need to sustainably intensify production without converting increasingly protected forests or natural vegetation into cropland or relying on expensive land expansion. Investments in production efficiency, adoption of technologies that reduce emission intensity, land ownership, access to emerging market segments and income from diversified revenue streams will play a pivotal role in maintaining Brazil's current dominance in the global soy sector and enabling producers to lean into climate transition opportunities.

Stakeholders across the Brazilian soy sector can capitalize on a range of emerging opportunities under climate transitions, provided they take action soon. Under our least ambitious below 2°C warming pathway, a projected 88 percent increase in agricultural investment incentivized by increasing competition for agricultural land would drive the average yield per hectare for soy farmers up by 14 percent between 2020 and 2050. Rising yields would contribute to an 8 percent increase in the land use efficiency of crops over the same period. This would allow producers to increase output on existing land rather than relying on growth fueled by the expansion of agricultural lands through converting natural vegetation into farms, which is expected to become increasingly costly and infeasible as government policies are strengthened and the bioeconomy scales.

Meanwhile, despite a 3 percent reduction in domestic soy demand in the face of unprecedented market transitions, global demand for soy products is still expected to increase by 14 percent by 2050 compared to 2020. Brazil could profit from this growing global demand for soy but only if its producers are able to meet rising international expectations about climate change and sustainability. The European Union is already requiring soy imports to be certified deforestation-free through supply chain due diligence legislation and other major importers are enacting or considering similar measures.[1] Scaling the shift toward more sustainable, forest-friendly and efficient agricultural practices would allow Brazil to increase soy exports by 6 percent despite global soy trade declining by 5 percent by 2050.

Diversification opportunities are similarly expanding for landowners to earn sustainable revenue through Brazil's newly emerging regulated market for carbon credits and the scaling voluntary carbon market, which both provide opportunities to measure and receive payments for the storage or removal of carbon dioxide from the atmosphere via reforestation and conservation. As the cost of GHG emissions become increasingly

[c] See Section 6 for a definition of "Low Performance farms."

## MARKET LEADERS WILL CONSIDER A RANGE OF FUTURE PATHWAYS TO NAVIGATE CLIMATE TRANSITIONS

Understanding the impact of multiple future transition pathways will provide stakeholders with the decision-useful information needed to prepare for the myriad of financial risks and opportunities on the horizon. The pathways outlined in this report project the potential impacts of actions needed to limit global average temperature increases to between 1.5°C and 3°C above pre-industrialized levels. On the one hand, the most ambitious, innovation-centric, 1.5°C-aligned scenario projects the most significant risks for the Brazilian soy sector by 2050. Under this scenario, producers would see a 28 percent drop in soy prices and a 36 percent decline in cropland area, while an expected 133 percent rise in agricultural capital investment in sustainable innovation could increase the resilience of production, driving an 84 percent increase in yields, a 32 percent growth in exports and a 17 percent rise in production. On the other hand, the most conservative, 2°C-aligned reference scenario highlighted throughout this analysis, known as the Forecast Policy scenario, shows that even under less ambitious assumptions, the Brazilian soy sector can anticipate material impacts from climate transitions. These impacts include a projected 14 percent increase in yields for producers that pursue sustainable improvements alongside an 11 percent decrease in cropland area in 2050 compared to 2020 levels.

The full range of projected outcomes across climate transition pathways is outlined below:

| Economic Impact | **2.0°C Pathways by 2050** Change from 2020 to 2050 | **1.5°C Pathways by 2050** Change from 2020 to 2050 |
|---|---|---|
| Soy producer price | -16% to -15% | -28% to -10% |
| Yield | +14% to +18% | +16% to +84% |
| Production | +2% to +6% | -13% to +17% |
| Brazilian soy demand | -3% | -14% to -1% |
| Global soy demand | +14% | -4% to +12% |
| Brazil soy export | +6% to +13% | -13% to +32% |
| Global soy trade | -5% | -21% to -7% |
| Cropland area | -11% to -10% | -36% to -25% |
| Cropland use intensity | +8% to +10% | +10% to +74% |
| Agricultural capital investment | +88% to +94% | +96% to +133% |

Brazil's continued dominance in the global soy sector and its ability to mitigate financial risks will depend on the ability of key stakeholders to prepare for inevitable climate transitions.

internalized on financial statements through policies, trade mechanisms, supply chain commitments and investor risk assessments, producers and traders that reduce the emission intensity of production can access lucrative opportunities to build competitive advantage.

The ability of Brazilian producers to access these opportunities will depend on capital providers and the Brazilian government continuing to expand investments that help producers meet sustainable production targets and diversify revenue. Radical levels of collaboration within the soy sector and across agricultural sectors will be needed to secure economic resilience for Brazil's soy sector by 2050, as action to limit global warming intensifies climate transition risks for the sector. Coordinated policies, financing incentives and action across agricultural sectors to promote the sustainable intensification of cattle production would release pasture land for soy and forests, thus alleviating competition for land, reducing land prices and decreasing production costs for soy producers.

Investors can protect their investments by leading efforts to better understand the potential impacts of climate transitions on the Brazilian soy sector and by calling upon others across the soy sector value chain and the government to support solutions that would enhance the sector's economic resilience. Brazil's continued dominance in the global soy sector and its ability to mitigate financial risks will depend on the ability of key stakeholders to prepare for inevitable climate transitions. As Brazil navigates the complex landscape of climate transitions, this report serves as a valuable guide for stakeholders seeking to make informed decisions in the face of evolving challenges and opportunities.

# Risks and Opportunities in the Brazilian Soy Sector

*Eight main trends drive these findings*

**Emissions pricing**

Greenhouse gas emissions pricing could materially drive up production costs for emission-intensive soy producers and create opportunities to diversify revenue streams.

**Land constraints**

Climate action, land conservation measures and competition for land from the bioeconomy could reduce the availability of affordable cropland land by up to 36 percent between 2020 and 2050.

**Yield improvements**

As business models reliant on high land use and deforestation become less feasible, soy producers can adapt by prioritizing sustainable productivity investments and process improvements to boost the yield on existing land.

**Modest production growth**

Production increases are supported by the implementation of low-cost yield-enhancing technology and sustainable management practices.

**Accelerating investment**

Investment in capital goods, land, advanced technology adoption and improved management practices could increase production efficiency.

**Soy price declines**

Producer prices could decrease due to changing soy demand and lower production costs driven by technological innovation.

**Consumer preference changes**

The demand for ruminant meat feedstocks could decrease under transition scenarios, but the diverse range of downstream soy applications may offer some resilience in international markets.

**Competitive advantage in exports**

Brazil has the potential to grow its competitive advantage for deforestation-free, low-emission and high-yield soy under climate transitions, increasing exports despite a decline in global traded soy volumes.

# Brazilian Soy Sector Transition Risks

The reference pathway highlighted here aligns with a 2°C world and showcases the implications of climate transitions already forecasted by the Principles for Responsible Investment.

**USD 617**

Without adapting to climate transitions, today's Low Performance farms would experience profitability declines of over USD 617 below 2020 levels by 2050.

Financial loss could surpass

**60%**

for a large proportion of producers by 2050 due to volatility from economic shocks common under climate transitions.

**11%**

reduction in cropland areas by 2050 compared to 2020.

Producers that fail to invest in sustainable management practices risk financial loss as early as

**2030**

**15%**

decrease in soy prices for producers by 2050 compared to 2020.

**3%**

reduction in domestic Brazilian soy demand by 2050 compared to 2020.

# Brazilian Soy Sector Transition Opportunities

The reference pathway highlighted here aligns with a 2°C world and showcases the opportunities of climate transitions already forecasted by the Principles for Responsible Investment.

**6%**

increase in exports by 2050 compared to 2020.

**14%**

increase in global soy demand by 2050 compared to 2020.

**8%**

increase in cropland intensity across Brazil by 2050 compared to 2020.

**83%**

profitability increase for High Performance farms due to technological innovation by 2050.

**1,356**

MMT $CO_2$/yr decrease in net $CO_2$ emissions from land use change by 2050.

**USD842**

Low Performance farms without land rent payments could increase 2050 profitability by USD 842 more than peers with land rent payments.

**14%**

increase per hectare in Brazilian soy yield by 2050 compared to 2020.

**2%**

increase in Brazilian soy production by 2050 compared to 2020

**88%**

growth in capital investment in Brazilian agriculture by 2050 compared to 2020.

# Definitions

**Agriculture, Forestry and Other Land Use (AFOLU):** A category used for greenhouse gas accounting encompassing a range of land-based practices, including agriculture, forestry and land use changes.

**Biodiversity Credits:** A financial instrument that assigns a measurable value to the conservation or restoration of biodiversity. Entities can purchase these credits to offset their ecological impact. This market-based approach creates a financial incentive for sustainable practices, allowing the trading of credits to strike a balance between economic activities and environmental conservation.

**Cap-and-Trade System:** A carbon pricing strategy that sets a limit on total greenhouse gas emissions. Entities receive allowances, and those emitting less can sell excess permits to those exceeding their limits. This market-based approach incentivizes emission reductions efficiently and allows flexibility in meeting targets.

**Carbon Credits:** Carbon credits are tradable permits representing the right to emit one metric ton of carbon dioxide or its equivalent. They are used as a mechanism to reduce greenhouse gas emissions by allowing entities to buy and sell credits based on their emission levels, encouraging emission reductions and investments in cleaner technologies.

**Carbon Dioxide Equivalent ($CO_2e$):** A standard unit used to express the total impact of various greenhouse gases in terms of the amount of carbon dioxide that would have the same global warming potential. Allows for the comparison of methane, nitrous oxide and carbon dioxide.

**Conference of the Parties (COP):** The decision-making body of the United Nations Framework Convention on Climate Change (UNFCCC), where member countries meet annually to assess and negotiate international climate policies and agreements.

**European Union Deforestation-Regulation (EUDR):** An update to existing European Union import restrictions prohibiting the sale of commodities — soy, beef, palm oil, wood, cocoa, coffee and rubber — sourced from regions affected by deforestation or forest degradation.

**Inevitable Policy Response (IPR):** A climate response scenario developed by the UN PRI that aims to prepare institutional investors for the portfolio risks and opportunities associated with the projected acceleration of policy responses to climate change.

**MMT:** Million metric tons.

**MMT DM/yr:** Million metric tons of dry matter per year

**Nationally Determined Contribution (NDC):** Voluntary greenhouse gas emission reduction targets submitted under the Paris Agreement detail each country's strategy toward adapting to and mitigating climate impacts.

**Pricing Greenhouse Gas Emissions:** A market-based strategy that assigns a cost to carbon emissions utilizing a range of mechanisms (e.g., carbon tax) to encourage entities to reduce their greenhouse gas output. The strategy provides a financial incentive for companies to adopt cleaner practices.

**Principles for Responsible Investment (PRI):** Supported by the United Nations, these principles have been signed by investors with over USD 121 trillion in assets under management. Voluntary principles guiding investors to integrate environmental, social and governance (factors) into their decision-making processes promoting sustainable and responsible investment practices.

**Task Force on Climate-Related Financial Disclosures (TCFD):** A framework that guides companies in the voluntary disclosure of climate-related financial risks and opportunities. It provides a standardized approach for reporting on governance, strategy, risk management and metrics related to climate impact. Disclosure assists investors and financial stakeholders in assessing the climate-related aspects of a company's operations and strategies.

**The Paris Climate Agreement:** An international treaty adopted in 2015 under the UNFCCC. It seeks to limit global warming to below 2 degrees Celsius through voluntary commitments to emissions reductions.

**World Business Council for Sustainable Development (WBCSD):** A global organization of 200 leading businesses working to advance sustainable development through environmentally and socially responsible practices.

**Biodiversity Hotspots:** Regions characterized by exceptionally high levels of species diversity and endemism and valuable targets for conservation efforts due to their unique ecosystems.

**30x30 Initiative:** A conservation goal aimed at protecting at least 30 percent of the world's land and oceans by the year 2030. Seeking to address biodiversity loss, habitat destruction and climate change by establishing protected areas, marine reserves and other conservation measures to safeguard ecosystems.

**Land Use Change (LUC)**: The process by which the purpose or function of a piece of land is altered, typically involving a transition from one land use category to another. This can include transformations, such as converting natural landscapes (e.g., forests, grasslands) into agricultural fields, urban areas or industrial zones.

**Nitrogen Use Efficiency (NUE):** How effective crops utilize nitrogen inputs, such as fertilizers, to produce plant biomass or yield. It measures the ratio of nitrogen taken up by plants to the total amount of nitrogen applied to the field.

**Loss probability:** The probability of costs exceeding farm revenue in a particular year.

**Non-Timber Forest Products (NTFPs):** Items harvested from forests excluding traditional timber, encompassing goods like fruits, nuts, fungi, fibers, charcoal, honey, fish and game, among others, from existing forestry or agroforestry systems.

**South Atlantic Subtropical Anticyclone**: A high-pressure system located over the South Atlantic Ocean, characterized by clockwise circulation of air across the southern hemisphere. It influences weather patterns in the region, including the formation of trader winds and the steering of tropical cyclones.

# Introduction

*Climate transitions present disruptive financial risks that are already shaping the soy sector in Brazil in ways that will drive stakeholders to adapt their practices and investments.*

## Opening

The future of the sector will look very different from its past due to its exposure to both the physical impacts of climate change and the risks stemming from the emerging global response to climate change.

To maintain or increase profits and ultimately build resilience in an ever-changing world, the Brazilian soy sector will have to adapt to mitigate risks and lean into emerging transition opportunities both in Brazil and abroad. Producers, traders, downstream companies and financiers planning for these transitions will be best positioned to withstand them and reap the benefits of emerging opportunities.

The financial materiality of climate transitions depends on the pace of change and the ability of stakeholders to adapt. Low-productivity business models in the soy sector traditionally reliant on deforestation and land use change for economic expansion will be most vulnerable to financial losses as land prices increase. Conversely, market leaders must proactively assess and mitigate exposure to transition risks while identifying future opportunities.

The financial materiality of climate transitions depends on the pace of change and the ability of stakeholders to adapt.

This report integrates climate and economic modeling with spatial analysis and financial stress testing to illuminate climate transition risks and opportunities at the national, subnational, sectoral, firm and asset levels. Four climate transition scenarios, alongside Business as Usual, shed light on the impacts of climate transitions on the Brazilian soy sector between now and 2050. These reflect the consequences of actions aligned with limiting climate change to 1.5°C and 2°C above pre-industrial levels, while Business as Usual represents a world with over 3°C of warming.

### What Are Climate Transitions?

Climate transitions result from the government, private sector and civil society responses to climate change. As the physical impacts of the climate crisis intensify, these groups are under mounting pressure to adopt policies and regulations to shift behavior to mitigate the worst impacts of climate change and to achieve political objectives on climate change, such as the Paris Agreement's goal of limiting global warming to 1.5°C. Climate Transitions, as defined by the Task Force on Climate-related Financial Disclosures (TCFD), can be divided into four categories: policy/legal, technology, market and reputational. The scale of future risks and opportunities for actors in Brazil's soy sector depends on how producers proactively assess and manage these transitions.

Even in the least ambitious transition scenario, the Forecast Policy scenario, climate transitions will materially change the future of the Brazilian soy sector. This projection is highly plausible and aligned with the Inevitable Policy Response (IPR) scenario developed by the UN-supported Principles of Responsible Investment (PRI). These principles have been signed by investors with over USD 121 trillion in assets under management.

Market leaders can analyze the full range of scenarios to prepare for potential outcomes under climate transitions by mitigating disruptive risks and identifying new opportunities in a changing world. Those who make decisions based on forward-looking modeling will be best positioned to invest in higher and more resilient activities capable of weathering a range of climate transition shocks. Although the pace and scale of climate transitions is yet to be seen, it is clear that they have already created a new operating environment and their impacts will only intensify over the decades to come.

# The Brazilian Soy Sector is Evolving to Meet International Demand

*Market conditions are quickly evolving amidst increasing exports, accelerating climate risks and heightened pressure to invest in sustainable production practices.*

## Section 1

Including biodiesel, soy supply chains contribute 2.05 million jobs across the country, reflecting an 80 percent increase since 2012.

Soy is central to Brazil's economy, representing 46 percent of the country's annual crop production value and generating gross revenue of USD 86.9 billion in 2020.[2] [3] The soy industry has grown rapidly since the 1960s, culminating in Brazil's position as the leading soy producer today.[4] Brazil's production of around 162 million metric tons in the market year 2022/2023 represents a historic high, with output having nearly doubled over the past decade.[5] Soy yield per hectare experienced similar growth, from 2.9 t/ha in market year 2013/2014 to 3.4 t/ha in 2023/2024.[6]

In addition to playing a key role in the domestic economy, Brazil dominates the global soy export market. Supplying international markets with more than 50 percent of soy traded globally, Brazil is also the world's largest soy exporter.[7] [8] More than 70 percent of the 78.7 million metric tons of soy Brazil exported in 2022 went to China, with significant exports also going to Spain, Thailand, Iran and the Netherlands.[9] Although it is also used in the production of consumer goods and biofuels, more than three-quarters of soy is used for livestock feed, making Brazilian soy a crucial part of the global food system.[10]

The significance of soybeans to the country's economy is monumental. Soy was the most exported product in 2022, facilitating transactions worth USD 46.7 billion.[11] The state of Mato Grosso led production with 27 percent of the Brazilian soy export value, followed by Rio Grande do Sul with 16 percent and Paraná with 12 percent, Goiás with 8 percent and Mato Grosso do Sul with 6 percent.[12]

The soy sector is a significant employer in the Brazilian economy. Including biodiesel, soy supply chains contribute 2.05 million jobs across the country, reflecting an 80 percent increase since 2012, as monitored by Cepea and the Brazilian Association of Vegetable Oil Industries.[13] During this time period, the role of the soy and biodiesel sectors as job creators in agribusiness has surged, accounting for 23.2 percent of agribusiness employment compared to 12.9 percent in 2012.[d] [14] [15] A majority of these roles are concentrated in agribusiness services, encompassing transportation, trade and storage.

### Illegal Deforestation Risk Analyzer

**Available at:**
orbitas.finance/brazil-illegal-deforestation-tool

This interactive tool is designed to understand the scale of illegal deforestation within the Amazônia, Cerrado and Pantanal biomes in Brazil. Users can leverage this tool to access information on total deforestation areas, proportion of illegal deforestation relative to the overall deforested areas and fines for illegal deforestation in each municipality.

The sector is dominated by only a handful of international exporters. Roughly two-thirds of the Brazilian soy market is controlled by just four companies, known as the ABCD group: Archer Daniel Mills, Bunge, Cargill and the Louis Dreyfus Company. Together, these traders control 64 percent of Brazilian soy sales and half of the country's crushing capacity.[16] Since 2014, when it acquired several domestic operators, the China Oil and Foodstuffs Corporation (COFCO) has begun to challenge the market dominance of the ABCD group. In 2020, state-owned COFCO exported an estimated 5 million tons of soy, making it Brazil's fifth-largest exporter.[17]

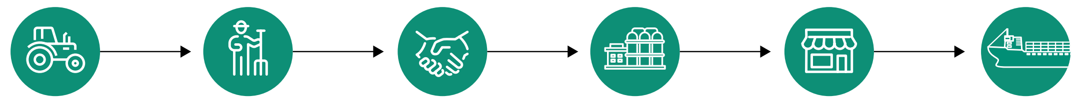
The soy sector's development over the past

[d] Note: Data was collected from Center for Advanced Studies in Economics (CEPEA) and the Brazilian Association of Vegetable Oil Industries (ABIOVE) and compared to Brazil's total agribusiness employment which was assessed from Trading Economics total Brazilian employment record and the World Bank's percentage of Brazilian employment in agribusiness.

FIGURE 1.

## BRAZILIAN SOY VALUE CHAIN

*Brazilian soy supply chains are complex and still lack transparency for downstream buyers and financiers.*



**Inputs**

**Crop management:**
- Land
- Seeds and fertilizer
- Pesticides and insecticides

**Farm operations:**
- Electricity
- Machinery
- Labor
- Maintenance
- Fuel and lubricants

**Farmers**

**41.6M** hectares in 2022

**162M** tons produced in 2022

**Crushers and traders**

**Dominant companies:**
- Cargill
- Bunge
- ADM
- Dreyfus
- Cofco

**Manufacturers**

**Biofuel Production:**
- Soy comprises 79% of Brazilian biodiesel

**Soy processing:**
- Over 99 soy crushing facilities operate throughout Brazil

**Retail and consumption**

**Downstream Sectors:**
- Biofuels
- Consumer-goods and products
- Food
- Chemicals
- Animal-feed

**Global Soy Usage:**
- Industry: 4%
- Animal feed: 76%
- Direct human consumption: 20%

**Market**

**78.7** MMT of soy exports in 2022
- Primary markets include China, Europe and the Middle East
- 70 percent was exported to China in 2022

Sources: United States Department of Agriculture (USDA), World Business Council for Sustainable Development (WBCSD), The Food and Agriculture Organization of the United Nations (UN FAO), United States International Trade Commission (ITC), Reuters and the United States Energy Information Administration (EIA).

> Preservation efforts in the Amazon have also inadvertently shifted deforestation activities to the Cerrado, a similarly ecologically important region that now faces the brunt of unchecked agricultural expansion.

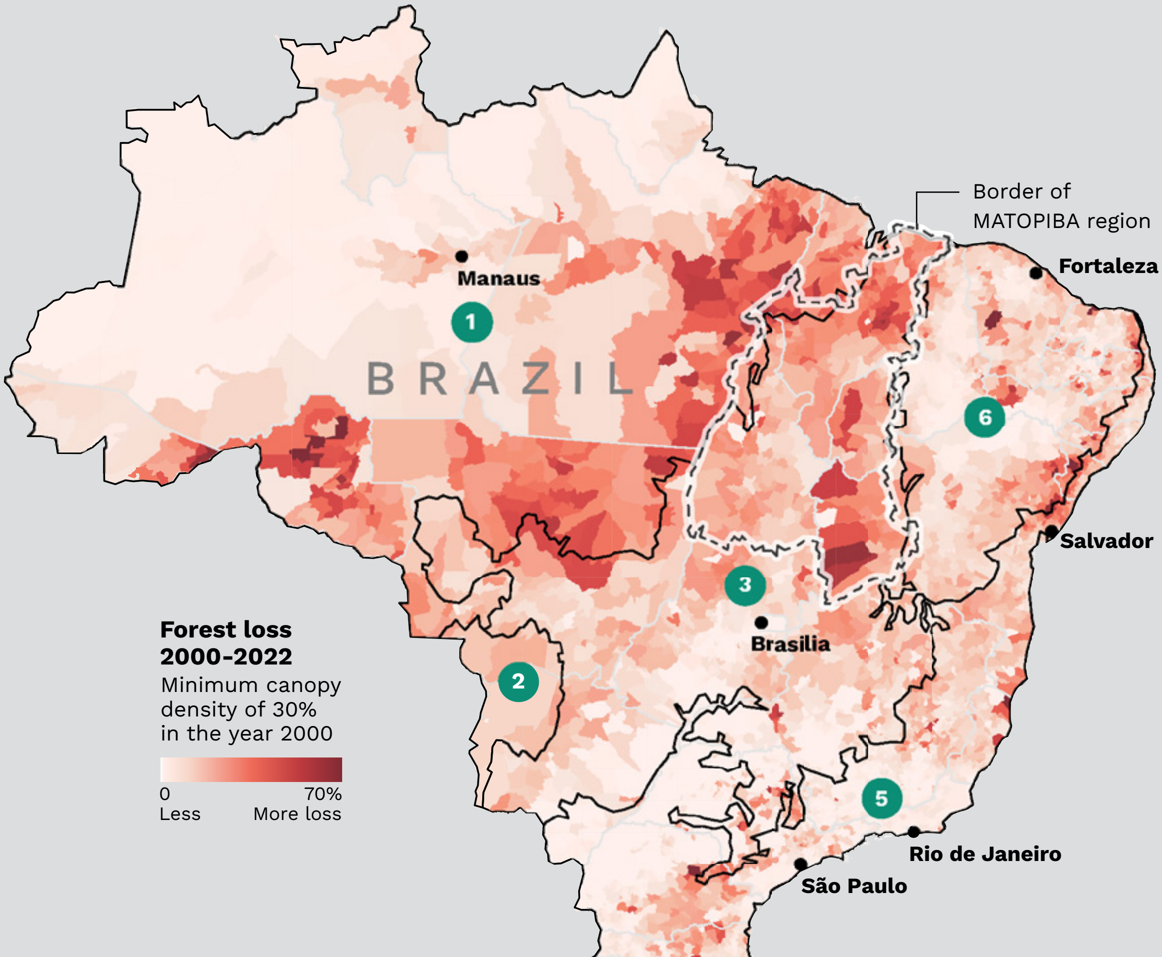
two decades has been shaped significantly by the Amazon Soy Moratorium. Signed in 2006 by the Brazilian Government, agribusiness players involved in the soy trade and various non-governmental organizations (NGOs), the Soy Moratorium committed traders to removing from supply chains any soy that originated from farmland deforested in the Amazon biome after 2008.[18] It has been highly effective, and by 2014, deforestation was linked to only 1 percent of soy expansion in the Amazon compared to 30 percent in 2004.[19] Instead of clearing virgin rainforests, land previously deforested for use as cattle pasture is now commonly converted to soy fields, an affordable alternative that has halved soy expansion.[20] However, preservation efforts in the Amazon have also inadvertently shifted deforestation activities to the Cerrado, a similarly ecologically important region that now faces the brunt of unchecked agricultural expansion.[21] Despite improvements in monitoring and restrictions on new native vegetation clearing, 41.8 percent of annual soy emissions are still tied directly to land use change practices.[22]

The states responsible for the majority, 65 percent, of Brazilian soy production are Mato Grosso with 26 percent, Paraná with 25 percent and Rio Grande do Sul with 14 percent.[23] These states continue to see significant land degradation, as spent soy fields are abandoned yet unable to return to the forest. These regional dynamics result in variations in embedded carbon among soy exports. For example, the European Union receives soy primarily produced from the deforestation-heavy north with 0.77 $tCO_2e$ embedded per tonne of soy equivalent, whereas exports to Chinese markets account for 0.67 $tCO_2e$ per tonne of soy equivalent.[24]

Furthermore, the displacement of Indigenous and traditional peoples from their ancestral homes poses a risk to the preservation of their cultural and traditional knowledge and alters their ways of life. The conflicts arising from illegal invasions into Indigenous and traditional territories can escalate violence in these regions, putting the people who live there at risk while also raising concerns about human rights abuses along soy supply chains.[25]

# UNDERSTANDING SOY PRODUCTION ACROSS BRAZILIAN TERRESTRIAL BIOMES

*Brazil boasts favorable climatic conditions for soy production, but the destruction of ecosystem services may threaten competitive advantage.*




## 1 The Amazon

**The biome:** Largest tropical forest on the planet supporting many species. Nearly 60% of the forest lies within Brazil, covering around 60% of its land.

**The challenge:** Population growth has led to conflict between the needs of the biome and economic development.

**The soy sector:** Despite regulations like the soy moratorium more than 100,000 hectares of forest have been converted to soy farms over the past decade across the states of Acre, Amapa, Amazonas, Maranhao, Mato Grosso, Para, Rondonia, Roraima and Tocantins.

## 2 The Pantanal

**The biome:** The largest tropical wetland on the planet, soaking up enough water across central South America to flood nearly 156,000 km² of plains during rainy seasons.

**The challenge:** Low-impact, sustainable livestock farming has preserved around 80% of the vegetation, but cattle farming and infrastructure expansion threaten its future.

**The soy sector:** Soy farmland only occupies a small portion of this region but is expanding around the springs that feed the Pantanal.

## 3 The Cerrado

**The biome:** Defined by its grasslands, savannas, and dry forests, the Cerrado is the second largest biome in South America, covering around 21% of Brazil. and home to 30% of its biodiversity.

**The challenge:** The MATOPIBA region of the Cerrado has experienced significant agricultural expansion, due to its favorable climate and legal protections provided by Brazil's Forest Code which permits the clearing of up to 65% of areas recognized as grasslands there.

**The soy sector:** Home to over half of Brazil's soy production with 18.2 million hectares in 2019.

## 4 The Pampas

**The biome:** One of the largest natural grasslands in the world encompassing 70 million hectares between Argentina, Uruguay, Paraguay, and Brazil, and once a biodiversity hotspot.

**The challenge:** With a focus on soy cultivation increasingly favored by cattle farmers for better cattle digestion, there has been a loss of biodiversity and 3.3 million hectares of native vegetation since 1985.

**The soy sector:** In 2020, soy was produced across 196,000 hectares of recently deforested territory.

## 5 The Atlantic Forest

**The biome:** The most populous region of Brazil, once thought to be the second largest rainforest in the world.

**The challenge:** Native vegetation comprises half of the territory it once did, with only 7.3% of the original forest remaining today.

**The soy sector:** Responsible for immense agricultural productivity, producing 35 million tons of soy in 2020, 29 percent of Brazil's annual production.

## 6 The Caatinga

**The biome:** Subject to limited rainfall shrubs and thorny forests dominate much of the region.

**The challenge:** The region is heavily dependent on low yield agriculture with 26% of the population working in agriculture, but extensive cattle farming practices have resulted in significant environmental degradation.

**The soy sector:** The region is home to limited soy production due to insufficient rainfall.

Sources: Global Forest Watch, Forest-GIS, Instituto Brasileiro de Geografia e Estatística, The World Bank, University College London, Institute de Brasilia

# Rapidly Materializing Physical Risks Are Making Climate Transitions Inevitable

**Section 2**

*Materializing physical risks are closely followed by heightened transition risks, as regulators, private sector actors and civil society have no choice but to act.*

Broad shifts in atmospheric conditions critical to agricultural productivity are threatening the availability of water in a region responsible for over half of Brazilian soy production.

Both human-caused climate change and regional deforestation pose threats to agricultural systems in Brazil. Physical climate risks are well known to the soy industry, as the financial implications of extreme weather conditions materialize. In 2022, drought in Rio Grande do Sul caused a record loss for producers, according to the Federation of Agricultural Cooperatives of Rio Grande do Sul (Fecoagro – RS).[26] Nearly half of the early 2022 harvest was lost, resulting in estimated financial losses of over USD 7.2 billion. In one municipality, Giruá, there was a reduction from 60 to 5 Brazilian bushels[e] of soybeans harvested per hectare.

In Mato Grosso, excessive rain and high humidity in 2021 led to the loss of up to 100 percent of soybean production on some properties. According to the Soybean Culture Survey conducted by Climate Fieldview in 2022, climate-related losses are the primary concern for 72 percent of soybean producers.[27] In the 2022 "Top 10 Risks and Opportunities for Agribusiness" report by EY, based on interviews with executives from Brazil, Argentina and Chile, the effects of climate change emerge as the most significant business concern.[28]

Regional land conversion and deforestation have already reduced evapotranspiration from the ground, increasing daytime temperatures and reducing air humidity.[29 30 31] Further, global climate change has strengthened the South Atlantic Subtropical Anticyclone, increased atmospheric pressure over the Brazilian tropical regions and transferred humidity to the south of Brazil. Therefore, important agricultural areas in the Brazilian tropical region are expected to be affected by reduced rainfall in the coming years (Figure 2).[32 33]

Hotter and drier conditions threaten crop and animal health, depress yields and compound the effects of extreme heat and drought events. Across Brazil, worsened droughts, extreme flood events and reduced soil productivity increase the likelihood of financial losses. Researchers from the Federal University of Minas Gerais (UFMG) provide evidence that changes in climate between 1961 and 2020 have impacted agricultural productivity. Despite increasing average productivity by 190 percent during this period, Brazil could have achieved an additional 20 to 25 percent increase without the effect of climate change.[34] Comparing weather station data between two 30-year intervals,

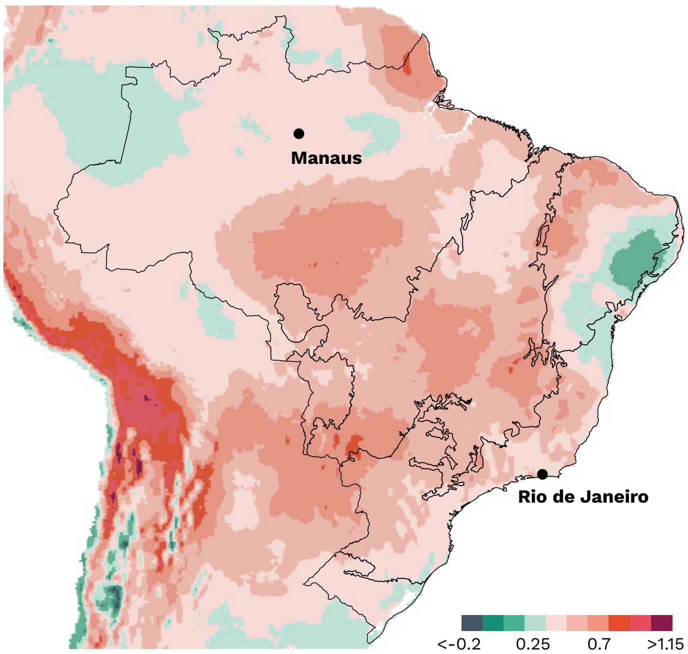
e One Brazilian bushel, or 'saca' is equivalent to 60kg

FIGURE 2.

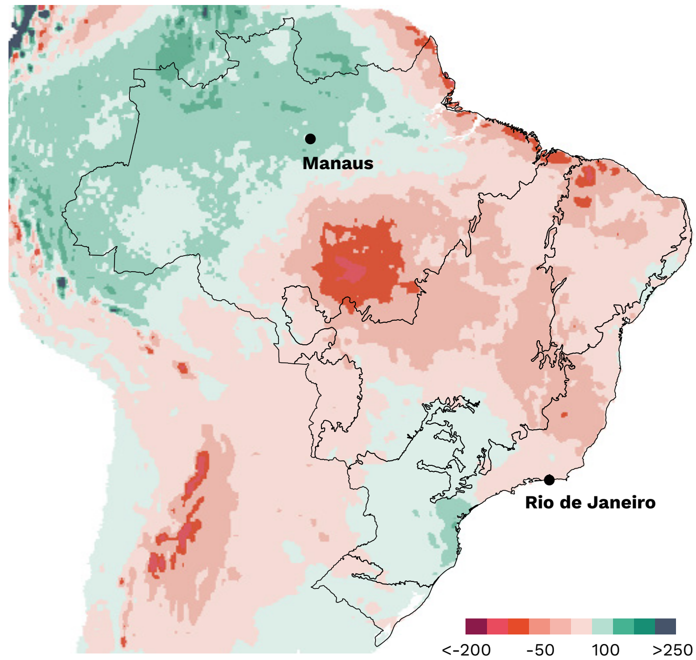
## REGIONAL CLIMATE CHANGES BETWEEN THE CLIMATE NORMALS 1991–2020 AND 1961–1990.

*The physical impacts of climate change are evident across Brazil.*

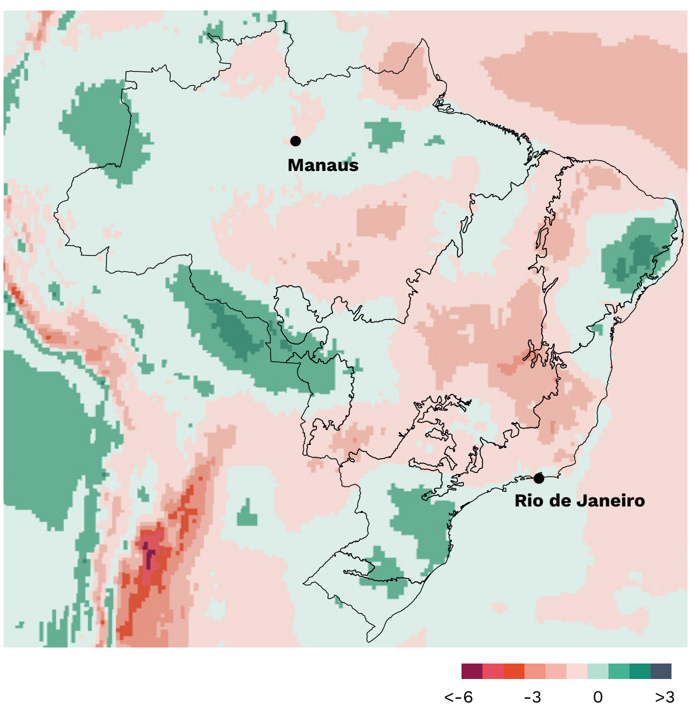
**Changes in Mean Temperature (°C)**
(Between 1961-1990 and 1991-2020)



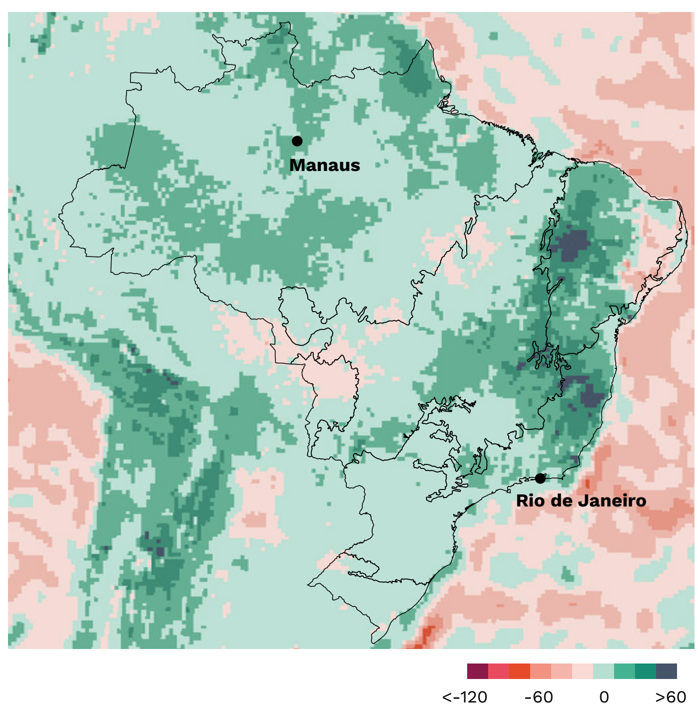

**Changes in Rainfall (mm)**
(Between 1961-1990 and 1991-2020)




**Changes in Relative Humidity (%)**
(Between 1961-1990 and 1991-2020)




**Changes in Evaporation (mm)**
(Between 1961-1990 and 1991-2020)




Source: Authors' economic modeling. Data: Brazilian National Meteorological Institute (INMET – Instituto Brasileiro de Meteorologia).

Notes: Regional climate changes detected by ERA5 reanalysis for Brazilian biomes between the climate normals 1991–2020 and 1961–1990. The negative values in the change in evaporation figure represent an increase in evaporation according to the pattern of reanalysis of ERA5. See Appendix 1 for a complete comparison of climate normals between 1991–2020 and 1961–1990 in Cerrado and MATOPIBA.

The wide-ranging impacts on livelihoods, food security, natural resources and health brought on by physical climate change risks make accelerating climate transitions inevitable.

1961–1990 and 1991–2020, shines light on the changing conditions the Brazilian soy industry is already experiencing.

In the north of the country, including the Cerrado, broad shifts in atmospheric conditions critical to agricultural productivity are threatening the availability of water in a region responsible for over half of Brazilian soy production.[35] These accelerating changes threaten the financial security of agricultural producers who depend on rainfall for irrigation, which encompasses the vast majority of soy producers in Brazil. For example, rainfall provides approximately USD 1–3 billion in irrigation services to the 97 percent of Amazon agricultural producers that rely on it.[36] By contrast, southwest Brazil is projected to experience a substantial increase in total rainfall. As moisture shifts from northern Brazil, the prevalence of extreme flood events is projected to rise, threatening financial losses to farmers in the region.[37 38 39]

Furthermore, the advance of deforestation, particularly in the Amazon, is expected to dramatically alter rainfall patterns across the center-west and southeast Brazil, decreasing rainfall during the dry season and shortening rainy seasons. According to UFMD, "Considering a scenario of increasing deforestation in the southern portion of the Amazon biome up to 2050, the new areas opened up for livestock and grain production will generate an additional USD 20 billion income. However, this same deforestation will result in a loss of USD 186 billion in the already established production in the region."[40]

The lack of transparency in Brazilian soy supply chains often results in sweeping characterizations of producers across the sector, but farmers engaging in more sustainable production practices without links to deforestation have a lot to lose financially from deforestation caused by less sustainable competitors.

Finally, labor costs in regions exposed to forest fire smoke may increase due to the risk of worsening respiratory disease, which has emerged due to the rising frequency and intensity of wildfires.[41] These effects are driven by global climate change and compounded by regional land use change, which alters the land–atmosphere interactions crucial to maintaining the historical climate.

As society, the private sector and policymakers become aware of the financial impact of physical changes to Brazil's economy and agricultural producers mobilize to protect the natural resources that create Brazil's competitive advantage, the risk of abrupt climate transitions will rise.

The wide-ranging impacts on livelihoods, food security, natural resources and health brought on by physical climate change risks make accelerating climate transitions inevitable. The only unknown is the speed and scale of these transitions. Considering a range of possible climate transitions using forward-looking projections is, thus, essential to preparing the Brazilian soy sector for the risks and opportunities that will shape the future.

# Climate Transitions are Already Impacting the Brazilian Soy Sector

*Responses to the physical impacts of climate change among policymakers, civil society and private sector actors are accelerating rapidly.*

**Section 3**

Waiting to act will create more disruptive transitions in the future, which would compound the financial losses projected as worsening physical impacts are realized.

Governments, companies, financial institutions, civil society and consumers are all increasingly reckoning with the consequences of a warming climate as the cost and scale of the damage become more widely understood and as the window to mitigate the worst impacts quickly closes. The sooner these groups take action, the more time the Brazilian soy sector will have to adapt business models to an evolving world.

Conversely, waiting to act will create more disruptive transitions in the future, which would compound the financial losses projected as worsening physical impacts are realized. The main impact pathways for climate transitions, as outlined below, are policy and legal, market, reputational and technology.[f]

These risks are already materializing on financial statements across Brazilian soy sector supply chains, but producers, traders, downstream buyers and financiers that proactively adapt can significantly mitigate these risks and benefit from market opportunities presented by climate transitions.

## Policy and Legal Transitions: Domestic and International Climate Goals and Regulations

The new Brazilian administration, following the election of President Lula da Silva, has pledged to update the country's domestic climate goals, committing to remove an additional 400 million metric tons of $CO_2e$ from Brazil's prior standing targets. Meeting these climate goals would entail substantial emission reductions from the country's agriculture industry. Key low-carbon agriculture policies already passed by Brazil are already creating transition risk and opportunity, and this trend is expected to accelerate as Brazil takes a more central role on the global climate stage in the run-up to its leadership at the 2024 intergovernmental forum, G20, the 2025 UN Climate Change Conference (COP30) and the 2025 BRICS (Brazil, Russia, India, China, South Africa) summit with the group of major emerging economies.

On the international stage, new climate goals and regulations will have a significant impact on the Brazilian agriculture sector. At the 2021 COP26, the largest annual UN climate change conference, over 140 countries pledged to halt and reverse deforestation and land degradation by 2030, which was further formalized by the UN climate change conference in 2023 (COP28) agreement.[42] Meanwhile, major export markets, such as the European Union (EU), are already instituting new anti-deforestation regulations.[43]

In 2023, the EU passed a new Deforestation Regulation that mandates a due diligence statement for all products entering the market to verify that they were not produced on recently deforested or degraded land. The penalties associated with the law are steep and include exclusion from the EU market, confiscation of revenues and large fines. Nearly 80 percent of Brazilian agribusiness exports and 40 percent of the country's total exports to the EU are estimated to fall under the purview of this regulation.[44]

Similar regulations focused on preventing imports of soy products and other goods tied to illegal deforestation are being enacted in important export markets around the world, while China and Brazil continue talks to end illegal deforestation driven by trade.[45] [46] Failure to satisfy these new requirements could result in significant market access loss for Brazilian agriculture, while transparent supply chains will benefit from stable demand and potentially higher prices.

[f] According to the Task Force on Climate-Related Financial Disclosures, widely used by regulators enacting mandatory climate-related financial disclosures

# CLIMATE TRANSITIONS AFFECTING BRAZIL'S SOY SECTOR

*Climate transitions are materializing across every segment of the Brazilian soy supply chain*

**Transition risk type** Policy & Legal | Technology | Market | Reputation

Technology: Increased access to satellite monitoring tools allows for stronger enforcement mechanisms and supply chain due diligence practices.

Technology: Sustainable aviation fuels drive increasing demand for biofuels to reduce the carbon intensity of the airline industry.

Technology: Maturing of alternative-meat technologies could decrease demand for feedstock, while creating new market opportunities.

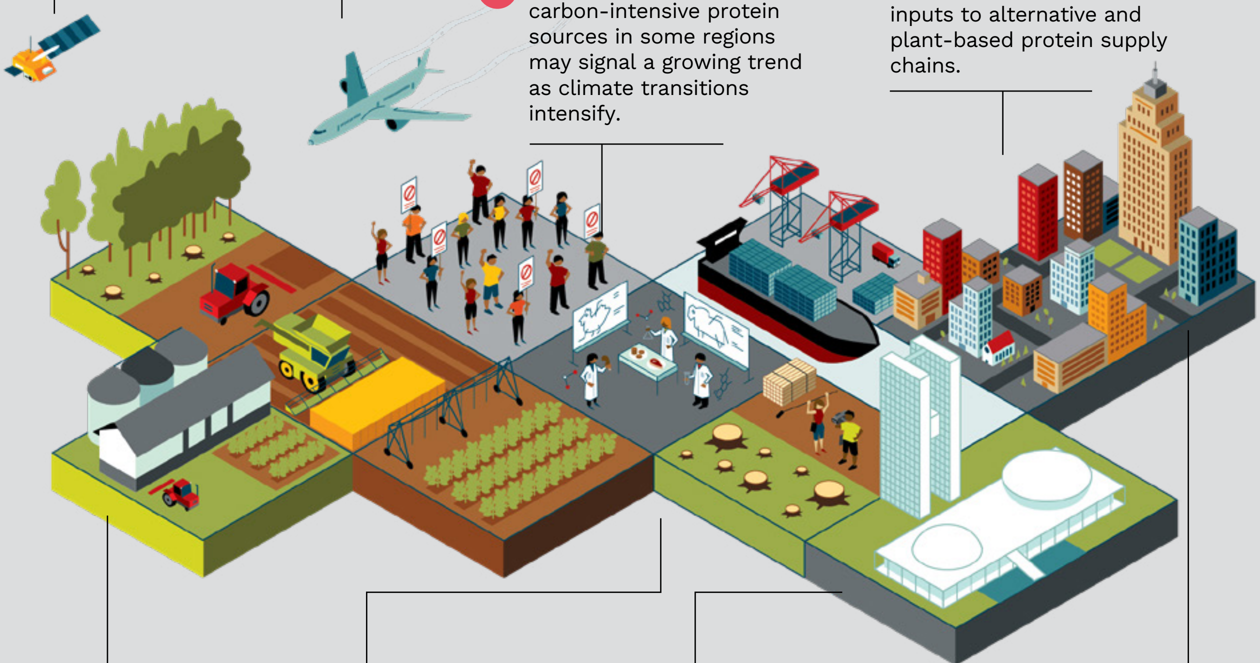
Reputation: Consumer preference changes can restrict market access for products with perceived links to deforestation and conversion as information dissemination accelerates.

Market: Declining demand for carbon-intensive protein sources in some regions may signal a growing trend as climate transitions intensify.

Market: Retailers, wholesalers, and traders require new environmental standards from their suppliers, creating market access risks for those that do not comply and opportunities for producers with strong policies.

Market: Corporate and consumer demand for deforestation-free, low-emission soy grows, creating strong demand for sustainable, transparent supply chains.

Market: Consumer preference for plant proteins increases demand for inputs to alternative and plant-based protein supply chains.



Technology: New planting technologies enable higher yields, diversified revenue streams, and emission reductions.

Technology: Increasing resource efficiency protects producers from rising land prices and competition.

Reputation: Increased stakeholder awareness about deforestation, nature loss and climate change increases scrutiny of tropical commodity supply chains.

Policy & Legal: Importing countries restrict or ban non-certified products or those associated with deforestation, impacting market access.

Policy & Legal: Government restrictions on deforestation reduce availability of land and increase land prices.

Policy & Legal: Introduction of greenhouse gas (GHG) taxes or pricing systems that either increase costs or offer revenue diversification opportunities for agricultural producers.

Reputation: Increased adoption of mandatory climate-related financial disclosures allows investors to assess risks more accurately in portfolio companies.

Reputation: Shareholders or capital providers divest or express concerns about environmental commitments in shareholder engagements or resolutions.

Market: Capital providers link financing to improvements in GHG emissions or deforestation and conversion-free commitments, allocating more resources to sustainable production.

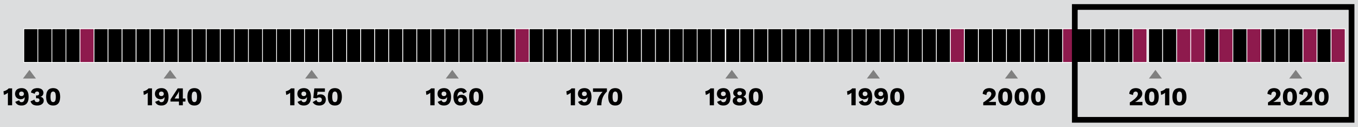
# THE EVOLUTION OF CLIMATE-ASSOCIATED AGRICULTURE POLICIES IN BRAZIL

*The landscape of climate regulations is quickly evolving as the government responds to accelerating climate impacts*

## POLICY MILESTONES

1930-2023

See next page for details




**1934**
**Forest Code:** Revised in 1965; Updated in 2012. Conserve native vegetation on private property.

**1965**
**The Rural Credit National System (SNCR):** In the 2023/2024 crop season, Plano Agrícola e Pecuário (PAP) encouraged sustainable production systems in medium and large farms by decreasing interest rates for recovery of degraded pastures.

**1996**
**National Program for Strengthening Family Agriculture (PRONAF):** Increase in resilience of family farmers and mitigate GHG emissions.

**2004**
**National Program on Biodiesel Production and Use (PNPB):** Target the production and use of biodiesel and stimulate rural development.

**The Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (PPCDAm) and Plan of Action for the Prevention and Control of Deforestation in the Cerrado (PPCerrado):** Reduce deforestation rates and achieve zero deforest-ation by 2030. PPCDAm revised and reactivated in 2023; PPCerrado revised in 2016.

### In progress

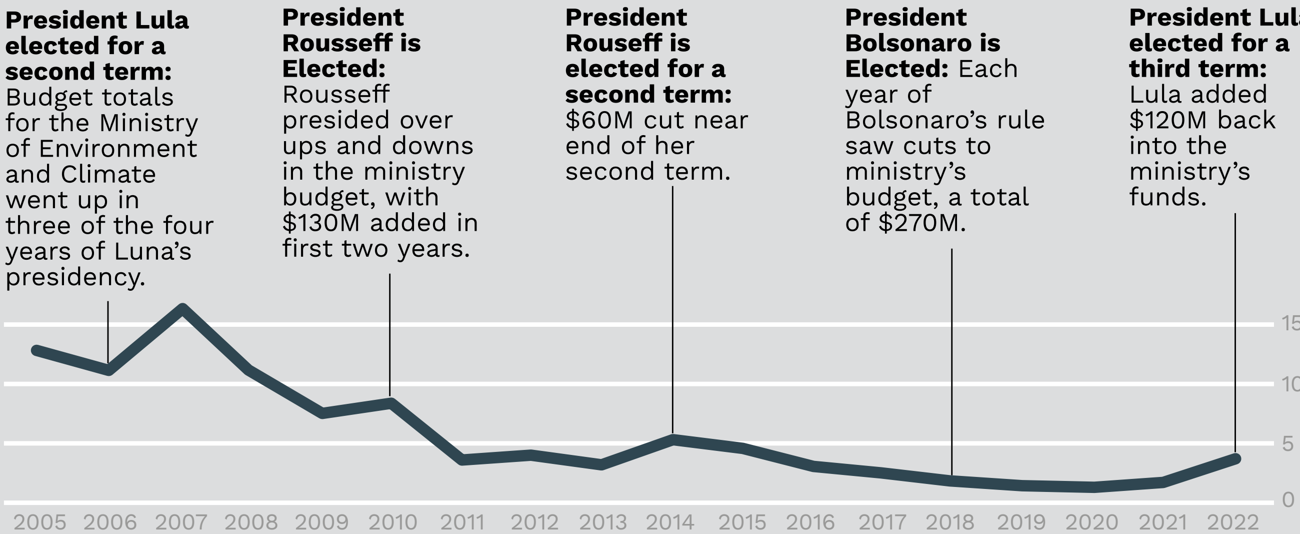
**Program to Recover Degraded Pastures:** Recover abandoned, degraded and low productivity pastures.

**The Brazilian Emissions Trading System (SBCE):** Cap-and-trade system that contributes to mitigating emissions and achieving NDC commitments, reducing physical risks

**Fuels of the Future Program:** Increase the use of sustainable fuels, reduce the average carbon intensity and promote the development of technologies.

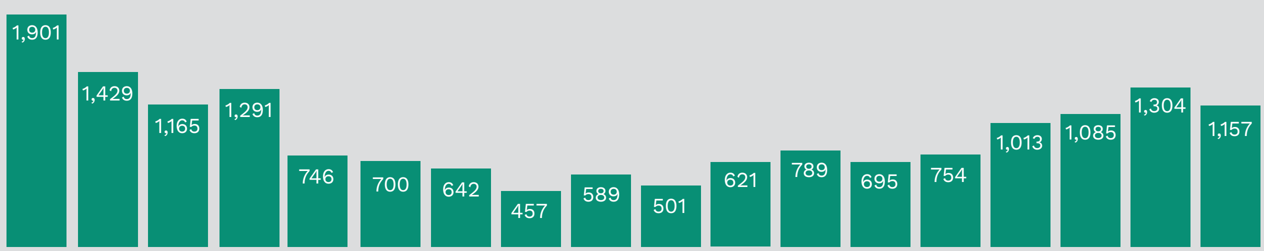
## GOVERNMENT SPENDING AND ACTION

Infraction notices issued in the legal Amazon, in thousands




## PRIMARY AMAZON FOREST LOSS

In thousands of hectares




| 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

**2009**
**The National Policy on Climate Change (PNMC):** Approved by the National Congress to achieve emissions reductions. The ABC Plan, PPCDAm and PPCerrado are three of the sectorial plans that form part of the PNMC.

**2012**
**The Sectorial Plan for Adaptation and Low Carbon Emission in Agriculture (ABC Plan):** Promote agricultural practices that reduce GHG emissions, increase efficiency and resilience of agricultural systems, and lower pressure on deforestation. New phase ABC+ in 2021.

**2013**
**The National Policy on Agroecology and Organic Production (PLANAPO):** Provide incentives to agroecology and organic agriculture through agricultural credits, technical assistance and research and development. Potentially increase resilience and reduce GHG emissions in agriculture by family farmers.

**2015**
**The Nationally Determined Contribution (NDC):** The most recent update in 2022 includes a target to reduce GHG emissions by 37% by 2025 and 50% by 2030, relative to 2005 emissions, while achieving climate neutrality by 2050.

**2017**
**National Biofuels Policy (RenovaBio):** Reduce emissions in the transportation sector and incentivize biofuel producers to increase the carbon efficiency of operations.

**2021**
**National Policy of Payments for Ecosystem Services (PNPSA):** Incentivize a market for eco-system services and create opportunities to recover deforested areas and protect natural vegetation.

**2023**
**Sustainable Finance Policy**: Support sustainable finance initiatives, combat greenwashing, enhance transparency and disclosure, foster the development of a suitable taxonomy and promote innovation.

CASE STUDY.

## Financier Efforts to Mitigate Reputational Risks in Investments

In 2019, 57 investors representing approximately USD 6.3 trillion in managed assets issued a statement outlining their expectations for companies involved in the soy trade. Voicing their concerns for regions such as the Cerrado and Gran Chaco, which have faced increased conversion away from native vegetation increases in recent years, the group outlined four key expectations intentionally aligned with the final recommendations of the Financial Stability Board's TCFD.

### Investor expectations

| | |
|---|---|
| **1. AWARENESS AND GOVERNANCE** | • Awareness and oversight of sustainability and deforestation issues at the board level.<br>• A publicly disclosed commodity-specific deforestation policy with a quantifiable, time-bound commitment covering the entire supply chain and sourcing geographies. |
| **2. RISK MANAGEMENT AND TRACEABILITY** | • Public disclosure of processes to identify, assess and manage deforestation risks across the soy supply chain. |
| **3. STRATEGY AND RISK MITIGATION** | • Public disclosure of the percentage of soy sourced from suppliers in compliance with the company's deforestation policy.<br>• Public disclosure of the protocol for supplier non-compliance, including requirements for a time-bound corrective action plan to return to compliance.<br>• Public disclosure of a time-bound strategy to reduce Scope 1, 2 and 3 GHG emissions. |
| **4. METRICS AND MONITORING** | • Public disclosure of the metrics used to identify, assess and manage soy-driven deforestation risks within the entire supply chain.<br>• Public disclosure of Scope 1, 2 and 3 GHG emissions, calculated in line with internationally recognized GHG estimation methodology and practices. |

As reputational risks intensify, industry actors will need to show investors that they can meet these expectations if they are to maintain access to capital.

Recent advancements in technology offer unprecedented opportunities for improved productivity and sustainability, which allow producers to reduce reliance on deforestation and land use change for expansion.

Finally, various stakeholders have recently begun urging relevant legal and regulatory systems to consider legal theories that regard failure to follow publicly declared sustainability commitments as fraudulent business conduct. This is evident most recently in a formal complaint filed with the Organization for Economic Co-operation and Development (OECD), alleging that a major Brazilian soy trader's failure to remove known deforestation and human rights abuses from their soy supply chain violated its stated commitments to end deforestation in the Amazon and Cerrado. A possible breach in the international code on responsible business conduct may result in significant consequences if acted upon by the relevant authorities.

## Technology Transitions: Advances in Science and Technology

Technological advancements in alternative protein technologies present real risks to the sustained demand for Brazilian soy as a feedstock, but plant-based proteins and biofuels offer opportunities to diversify revenue and mitigate the risk of declining ruminant meat demand by 2050.[47] The risk of losing access to international markets and supply chains is also increasing as companies, governments and civil society leverage affordable, real-time satellite imagery to monitor deforestation and land use change. However, recent advancements in technology offer unprecedented opportunities for improved productivity and sustainability, which allow producers to reduce reliance on deforestation and land use change for expansion.

One of the most notable innovations is the adoption of precision farming techniques, which leverage real-time data and sensor technology to monitor crop health and nutrition. This enables farmers to make informed decisions and optimize input regimes, ultimately enhancing growth rates. Additionally, the integration of satellite-based geospatial technologies and GPS tracking systems enables more efficient land management that reduces soil degradation. These technological advancements not only improve productivity but also contribute to environmental sustainability by reducing resource waste and mitigating the ecological impact of soy farming, making them pivotal tools for shaping the future of the Brazilian soy industry.

Researchers have made significant strides in developing innovative techniques for optimizing soil quality and quantity. This includes improved seed selection and precision fertilization methods that ensure crop resilience throughout the year. Furthermore, cutting-edge soil health assessments and sustainable land management practices are helping farmers restore degraded land and maintain healthier ecosystems. These scientific breakthroughs not only increase the carrying capacity of farmland but also contribute to reduced environmental impacts, making them a crucial component of sustainable and efficient soy ranching in Brazil.

While some producers in Brazil have been able to adapt and take advantage of these new opportunities, there remains a large segment of producers who could benefit from these opportunities if provided with the regulatory, financial and technical support to implement them. As production efficiency increases and emissions intensity decreases across the Brazilian soy sector, producers who do not adapt risk being outcompeted on the global market by those who do.

As production efficiency increases and emissions intensity decreases across the Brazilian soy sector, producers who do not adapt risk being outcompeted on the global market by those who do.

## Reputational Transitions: Risks Faced by Brazilian Soy Players

Reputational risks are becoming increasingly important to agricultural producers in Brazil due to the growing global awareness of deforestation and environmental sustainability. Significant improvements in satellite monitoring have enabled watchdog agencies, companies and financiers to more effectively monitor for signs of deforestation and degradation to prevent reputational risks, and those without monitoring risk public embarrassment when shortcomings are exposed by NGOs or journalists.

Negative perceptions by consumers and investors can impact companies' access to international markets and financing. Downstream buyers and investors with sustainability commitments and high brand values are particularly likely to respond to reputational risks, especially when they are located in countries or regions with strong climate disclosure requirements. Increasingly, players who fall short of sustainability commitments face allegations of greenwashing and are exposed to reputational risk to brand assets.

## Market Transitions: Corporate and Investor Climate Efforts

Corporate and investor efforts to meet increasingly ambitious climate goals will undoubtedly shape the future of Brazil's soy sector. Such efforts have proliferated in the last few years. At the 26th global UN climate conference, COP26, 10 of the world's largest companies heavily involved in global commodity production, signed a pledge to end deforestation in their supply chains by 2030.[48] Meanwhile, 30 leading financial institutions, with over USD 8.7 trillion in assets under management, collectively committed to eliminate agricultural commodity-driven deforestation from their investment and lending portfolios by 2025.[49]

Financiers have also raised significant concerns about protecting investments from reputation risks driven by deforestation. One such incident was in 2020, when a group of investors threatened divestment from Brazil's beef producers, grains traders and even government bonds, citing elevated country level risk caused by the risks from unchecked deforestation and a lack of transparency.[50]

Similarly, corporations along deforestation-risk supply chains are under pressure to eliminate deforestation from sourcing while working to improve mechanisms for financing producer resilience in the face of climate transitions. About two thirds of companies with high deforestation exposure have sourcing policies in place intended to mitigate these exposures, and this number is expected to grow as climate-related financial disclosure requirements are passed around the world and shareholders submit resolutions in favor of stricter policies and heightened monitoring.[51] Accelerating corporate and investor commitments prevents market access and financing for suppliers that do not meet these criteria.

## STRENGTHS, WEAKNESSES, OPPORTUNITIES AND THREATS FOR THE BRAZILIAN SOY SECTOR

*The Brazilian soy sector faces both significant challenges and unprecedented opportunities.*

Emerging carbon and biodiversity markets, sustainable intensification strategies and emerging markets for alternative proteins and biofuels offer proactive soy farmers the opportunity to diversify revenue streams and increase their profitability. Those that fail to respond to the evolving market risk significant challenges, as changing regulations, rising land and carbon prices and potential market access restrictions cloud the future of the Brazilian soy sector.

### Opportunities

- Rising consumer demand for zero-deforestation and low-emission soy.
- High potential to increase revenue and reduce costs through higher land use efficiencies, driven by innovative research and development (R&D), technical assistance, better management and infrastructure improvements.
- New opportunities for diversifying revenue streams through carbon and emerging biodiversity markets, along with other nature-based solutions.

### Threats

- New emission costs from production, processing and transportation with the appearance of GHG prices.
- Higher land prices due to deforestation restrictions and competition for land from growing commodity production and carbon market projects.
- Declining demand in soy for feed due to lower ruminant meat production.

### Strengths

- Concentrated midstream and downstream market power can efficiently allocate product processing and sales.
- Significant international market share.
- Established industry and supporting infrastructure.
- Strong track record of productivity improvements in recent decades.

### Weaknesses

- Limited and inconsistent deforestation enforcement.
- High transportation costs for farmers located away from demand centers, processing facilities and port facilities.
- Profitability is highly sensitive to soy price changes.
- Exports are heavily dependent on demand from a single market – China.

Source: Authors' analysis.

# A Glimpse into the Future of the Brazilian Soy Sector Through Economic Modeling

*Eight emerging trends stemming from climate transitions are likely to create risks and opportunities for stakeholders across the Brazilian soy sector.*

## Section 4

Brazil is in a unique position to seize upon opportunities to ensure that its soy sector stays competitive amidst these changes and to support the nation's rural economy for decades to come.

Climate transitions will create winners and losers in the global soy sector, driven primarily by shifting diets, technological change, improved management practices and declining land availability. Brazil is in a unique position to seize upon opportunities to ensure that its soy sector stays competitive amidst these changes and to support the nation's rural economy for decades to come.

Climate transition scenario analysis is needed to understand who will fare best under climate transitions and how best to manage them while providing a pathway to test for weak spots and potential opportunities across the Brazilian soy sector. By considering different scenarios of the future with alternative levels of climate action, technology adoption and more, stakeholders in Brazil's soy sector are better able to plan for the future. While it is impossible to know exactly how and what climate transitions will unfold in the future, utilizing this type of scenario analysis provides an opportunity to understand the range of future impacts and identify where new investments in resilience are most needed.

Through analyzing the impact of forward–looking projections (see Scenarios Explained box), it is clear that companies with high production efficiency, low rent costs, proximity to infrastructure — including demand centers, ports and processing facilities — access to capital and diversified revenue from nature-based solutions will survive and thrive on existing land. However, producers with higher operational and financial costs will find sustainable land intensification challenging.

Government and investor financing and increased agricultural productivity, particularly through technology and sustainable management practices, will play an important role in either enabling or hampering Brazil's global competitiveness. Sustainability and yield improvements can become the Brazilian soy industry's competitive advantage. Its position as a major global player allows Brazilian soy producers to set the tone for global standards in partnership with major importing regions.

### Chapter Highlights

The magnitude of the global response to climate change will dictate its impact on the Brazilian soy sector. Nevertheless, even the **below 2°C-aligned projections of the IPR-aligned Forecast Policy scenario** anticipate significant changes by 2050, as outlined below:

- Emission-intensive soy producers would experience rising costs and gain opportunities to diversify revenue streams through carbon markets as GHG prices grow.
- Climate action, land conservation measures and competition for land from the bioeconomy would reduce the availability of affordable cropland land by 11 percent.
- Producers would experience a 14 percent increase in yield.
- Production would increase by 2 percent.
- Capital investments in Brazilian agriculture would rise by 88 percent.
- Prices would decrease by 15 percent as technological innovation lowers production costs.
- Brazilian soy demand would decrease by 3 percent domestically, driven by the shift in consumer preference for ruminant meat reducing demand for feed.
- Brazil has the potential to grow its competitive advantage for deforestation-free, low-emission and high-yield soy under climate transitions, increasing exports by 6 percent despite a 5 percent decline in global traded soy volumes.

Projecting four versions of the future with 1.5°C-aligned or 2°C-aligned climate action, in addition to a version of the future that follows a Business as Usual trajectory, arms stakeholders with the information necessary to make informed decisions. Market leaders will prepare for the ambitious climate

# SCENARIOS EXPLAINED: PROJECTING A RANGE OF FUTURES FOR THE BRAZILIAN SOY SECTOR

*Each scenario considers both global and corresponding local pathways to achieve global warming temperature targets by 2050.*

## Business as Usual - Baseline with Warming Target > 3°C [g]

**Business As Usual Scenario:** The Business as Usual scenario assumes limited global and local ambitions to address the climate crisis, a continuation of current trends. This would mean that dietary shifts are not adopted, protected areas do not expand and little international ambition in support of climate action is realized. Agriculture, Forestry and Other Land Use (AFOLU) GHG emissions are priced at very low levels while limited deforestation prevention efforts are made. Although this scenario reflects the status quo, the acute physical risks to which the Brazilian soy sector is exposed will impact production much more than those depicted in the Business As Usual scenario, which covers only transition risks at a decadal scale.[52] Additional risks from extreme weather events, labor productivity effects, pests, diseases and animal heat tolerance will lower yields. The resulting inevitability of climate transitions means that the Business As Usual scenario paints a more optimistic picture of the future than the soy sector will face. A > 3°C world with extreme temperature, precipitation and humidity impacts would present an existential risk to profitability at Brazilian soy farms even if transition risks are lower.

## Modest Action with Warming Target < 2°C

**Forecast Policy Scenario:** The Forecast Policy (Modest-Forecast Policy) scenario is a component of the Inevitable Policy Response (IPR) scenario by the UN-supported Principles of Responsible Investment (PRI) and projects current policy forecasts through 2050 without substantial deviation from expected commitments. Medium dietary shifts and food waste reductions occur, low-ambition climate policies are introduced, and existing land protection policies are expanded across only critically important biodiversity hotspots. AFOLU GHG emission prices are projected to increase. However, values rise abruptly with strong regional variance.

**Coordinated Policy Scenario:** By contrast, the Coordinated Policy (Modest-Coordinated Policy) scenario is characterized by slightly more ambitious climate policies which are implemented sooner than in the Modest-Forecast Policy scenario. Comprehensive pledges for reforestation and reduced deforestation are observed throughout Brazil as effective management of biodiversity hotspots is ensured. Beyond land use policy, modest dietary shifts, food waste reductions, and AFOLU emissions prices are also a part of this scenario. However, these changes do not represent substantial societal shifts.

## Ambitious Action with Warming Target < 1.5°C

**Societal Transformation Scenario:** The Societal Transformation (Ambitious-Societal Transformation) scenario is characterized by strong societal transformation, amplifying actions taken under the Modest scenarios. AFOLU GHG emissions are priced higher and significant dietary shifts take place. This reduces livestock intake and food waste. In addition, protected areas double from the present ~15 percent to 30 percent by 2030, in alignment with the international 30 by 30 initiative. Deforestation is reduced and reforestation is increased.[53] This scenario also assumes medium technological and sustainable management practice change adoption.

**Innovation Scenario:** The Innovation (Ambitious-Innovation) scenario deviates from societal transformation, instead favoring innovative solutions to GHG-intensive processes. The most important projected shift is the intensive implementation of yield-enhancing practices, including technology adoption and fertilizer use efficiency. AFOLU GHG pricing rises to the levels observed under a broad societal transformation. This scenario assumes high technology and sustainable management practice adoption, spurred by research and development investments and high innovation diffusion across the sector.

[g] Orbitas is collaborating with World Business Council for Sustainable Development (WBCSD) and Vivid Economics to drive greater alignment around climate transition scenarios assumptions. The scenarios are based on the WBCSD transition scenario tool, which was inspired by Orbitas phase 1 scenarios, with modifications to incorporate recent developments. See here for the earlier WBCSD tool: https://www.wbcsd.org/Programs/Redefining-Value/TCFD/News/WBCSD-releases-new-climate-transition-scenario-tool-for-companies-in-the-Food-Agriculture-and-Forest-Products-sectors

> See **Appendix 2** for more information on scenario assumptions.

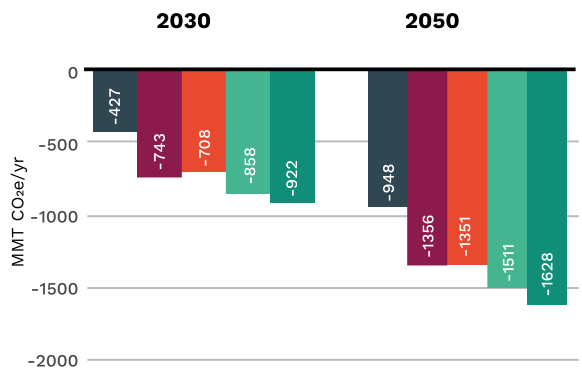
FIGURE 3.

## PROJECTED $CO_2$ AND $N_2O$ EMISSION REDUCTIONS FROM AGRICULTURE AND LAND USE CHANGE IN BRAZIL RELATIVE TO 2020

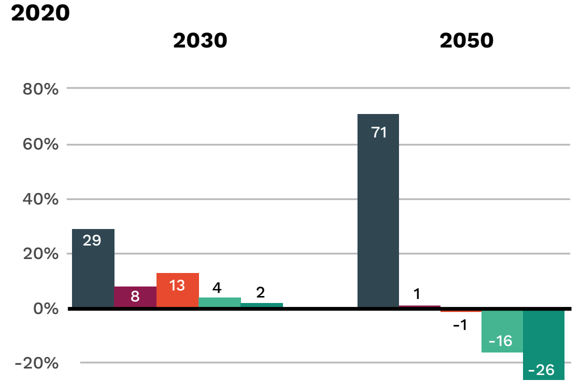
*As the world adopts carbon pricing and Brazil works to meet international commitments, land use change and agriculture emissions would decline.*

Business as Usual
Modest-Forecast Policy
Modest-Coordinated Policy
Ambitious-Societal Transformation
Ambitious-Innovation

**Projected net $CO_2$ emissions from land-use change relative to 2020**




**Projected percentage change in net $N_2O$ emissions from agriculture relative to 2020**




**In absolute values** (MMT $CO_2e$/yr)

| | Business as Usual | Modest-Forecast Policy | Modest-Coordinated Policy | Ambitious-Societal Transform-ation | Ambitious-Innovation |
|---|---|---|---|---|---|
| **2030** | 149 | 124 | 130 | 120 | 118 |
| **2050** | 197 | 117 | 114 | 97 | 86 |

Source: Authors' economic modeling (MAgPIE) results

**Brazilian nitrogen emission decrease:**

Across 2°C and 1.5°C transition scenarios, $N_2O$ emissions would drop up to 26 percent

transitions expected in a world that acts to restrict warming to 1.5°C above pre-industrial levels.

However, even transition scenarios aligned with 2°C of warming will significantly transform the Brazilian soy sector. The Forecast Policy scenario, aligned with the PRI's IPR initiative, represents a below 2°C-aligned reference scenario based on already forecasted policies to clearly show the scale of potential impacts that climate transitions will have on the Brazilian soy sector. This sheds light on the major trends that the Brazilian soy sector may face as climate transitions become increasingly inevitable, and the eight most material trends impacting financial outcomes are outlined below.

## Trend 1. Emissions Pricing

GHG emissions pricing could materially drive up production costs for emission-intensive soy producers and create opportunities to diversify revenue streams.

Key sources of emissions costs include $CO_2$ emissions from deforestation, conversion of carbon-rich ecosystems, fuel use for transportation and operation and nitrous oxide ($N_2O$) from fertilizer application to agricultural soils.

Even so, the Brazilian policies already enacted, but not fully implemented, show the low-emission potential of the entire Brazilian agricultural sector, even under the Business As Usual scenario. Implementing current policies could transform the Brazilian land use system into a net carbon sink in the short term and establish a broader low-emissions potential as a feasible medium-run target for the country. The Business As Usual scenario would see a drop in $CO_2$ emissions from land use change (LUC) as a result of reductions in deforestation projected with a full implementation of the Brazilian Forest Code.

Deeper reductions in the transition scenarios would result from the aggressive pricing of LUC emissions and more ambitious policies. The higher conservation commitments in designated biodiversity hotspots under the Modest-Forecast Policy scenario would drive a decrease in net $CO_2$ emissions from LUC of 1,356 million metric tons between 2020 and 2050. The higher land conservation implied by the 30x30 initiative in the Societal Transformation scenario would contribute to a larger reduction in LUC and lower $CO_2$ emissions. The largest reduction in LUC, however, would occur in the Ambitious-Innovation scenario due to more intensive farmland use and the high levels of yield-enhancing technological change (Figure 3).

**Brazilian soy forest cover increase:**

Across 2ºC and 1.5ºC transition scenarios, forest cover would increase between 11 and 27 percent

Projected $N_2O$ emission reductions are driven by the introduction of higher GHG prices and increased nitrogen use efficiency (NUE). Among transition scenarios, the largest reduction in agricultural $N_2O$ emissions would occur under the Ambitious-Innovation scenario as a result of efficient production technology and sustainable management practices.

**Brazilian soy cropland area reduction:**

Across 2ºC and 1.5ºC transition scenarios, cropland area would reduce between 10 and 36 percent

Increasing GHG prices also change the profitability equation for how land is used and make new revenue streams, such as carbon or biodiversity markets, non-timber forest products or new products from agroforestry more attractive. As production costs rise for emission-intensive producers, farmers with low profit margins may consider new business models.

## Trend 2. Land Constraints

Climate action, land conservation measures and competition for land from the bioeconomy could reduce the availability of affordable cropland land by up to 36 percent between 2020 and 2050.

Climate transitions are likely to constrain the Brazilian soy sector's geographic expansion, with projected declines of 10 to 36 percent between 2020 and 2050 (Figure 4). Historically, Brazilian soy industry expansion has often come at the expense of natural vegetation, either directly or indirectly, replacing cattle production on previously deforested pastures. Under climate transitions, growth that degrades or clears forests will not be feasible due to 1) the Brazilian government's deforestation commitments and 2) the potential for landowners to earn revenues from forest preservation and restoration projects, driving up opportunity costs.

**Greenhouse Gas Pricing**

These scenarios assume that GHG costs would be relatively minor in the early years but diverge across scenarios over time and increase substantially with greater climate ambition. As climate policies expand in response to worsening physical risks, scenarios project a GHG price increase to USD 87 per ton of $CO_2e$ under the Modest-Forecast Policy scenario, USD 100 per ton of $CO_2e$ under the Modest-Coordinated Policy scenario and USD 153 per ton of $CO_2e$ in 2050 under both Ambitious scenarios. GHG emission costs for soy farmers primarily stem from deforestation and the conversion of other carbon-rich ecosystems ($CO_2$) and fertilizer application ($N_2O$) and fertilizer. However, GHG pricing would also provide opportunities for farmers to diversify revenue streams through carbon and biodiversity markets.

The combination of strict climate policy and high-level land conservation ambition would contribute to lowering the environmental footprint but would also limit the overall land available for soy expansion. Projected forest growth by 2050 is a key factor in restricting geographical soy expansion potential.

Under the Business As Usual scenario, Brazil would see a net forest increase of only 1 percent from 2020 to 2050 as a result of the net-zero deforestation commitments already made. Under Modest scenarios, including Modest-Forecast Policy and Modest-Coordinated Policy scenarios, the forest area would increase by 11 percent by 2050 due to additional ambitious pledges for reforestation in support of the 2015 Paris Agreement.

The highest levels of GHG prices seen under the Ambitious scenarios, including the Ambitious-Societal Transformation and Ambitious-Innovation scenarios, would further incentivize land-based mitigation efforts and push natural vegetation to increase by

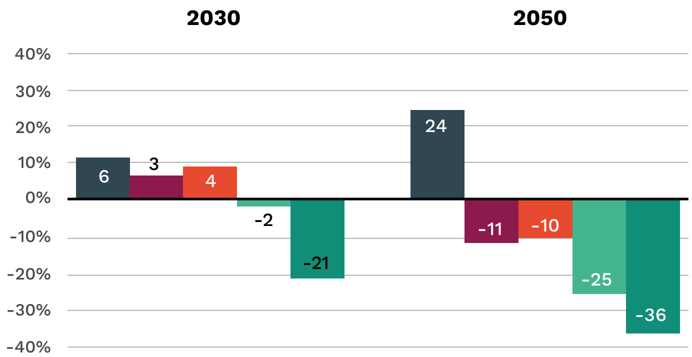
FIGURE 4.

## PROJECTED PERCENTAGE CHANGE IN BRAZILIAN LAND COVER RELATIVE TO 2020

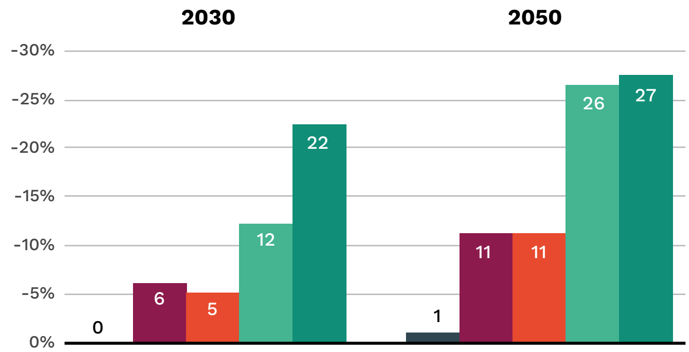
*As climate action leads to increased forest conservation, cropland will face heightened competition for land.*

Business as Usual
Modest-Forecast Policy
Modest-Coordinated Policy
Ambitious-Societal Transformation
Ambitious-Innovation

**Projected percentage change in cropland area relative to 2020**




**Projected percentage change in forest area relative to 2020**




**In absolute values** (Million ha)

| | Business as Usual | Modest-Forecast Policy | Modest-Coordinated Policy | Ambitious-Societal Transformation | Ambitious-Innovation |
|---|---|---|---|---|---|
| **2030** | 22.42 | 21.84 | 21.96 | 20.79 | 16.67 |
| **2050** | 26.33 | 18.90 | 19.07 | 15.83 | 13.52 |

**In absolute values** (Million ha)

| | Business as Usual | Modest-Forecast Policy | Modest-Coordinated Policy | Ambitious-Societal Transformation | Ambitious-Innovation |
|---|---|---|---|---|---|
| **2030** | 533 | 561 | 559 | 597 | 646 |
| **2050** | 536 | 589 | 587 | 667 | 675 |

Source: Authors' economic modeling (MAgPIE) results

The sustainable intensification of cattle production can alleviate this pressure by releasing pasture land for soy and forests

up to 27 percent, or 675 million hectares, in 2050 (Figure 4). All of the forest land cover increases contribute to land-based carbon sequestration but impose economic and legal restrictions on soy production.

The sustainable intensification of cattle production can alleviate this pressure by releasing pasture land for soy and forests, but soy farmers cannot directly control this, making key soy sector stakeholders heavily dependent on a livestock systems transition and coordinated policies, financing incentives and action across agricultural sectors.[54]

### How does innovation in the livestock sector impact the future of Brazilian soy?

Increasing the resource efficiency of Brazilian agriculture, including the sustainable intensification of both crop and livestock systems, is crucial to achieving land sparing at the scale needed to meet international climate commitments and maintain food security.

Although land would be used more intensively, it would also be used more sustainably, and less of it would be required for agricultural production, making land available for other uses. Technological change, including process innovation and machinery, would come as a result of increased investments into capital goods and land, increasing the factor productivity of capital, labor and land.

The potential for this in the livestock sector in Brazil is well documented and could lead to a reduction of several million hectares of pasture area without compromising production and creating space for additional cropland, reforestation and more.

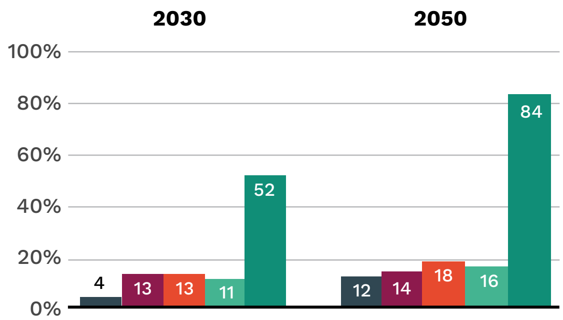
FIGURE 5.

## PROJECTED PERCENTAGE CHANGE IN BRAZILIAN SOY YIELD AND CROPLAND INTENSITY RELATIVE TO 2020

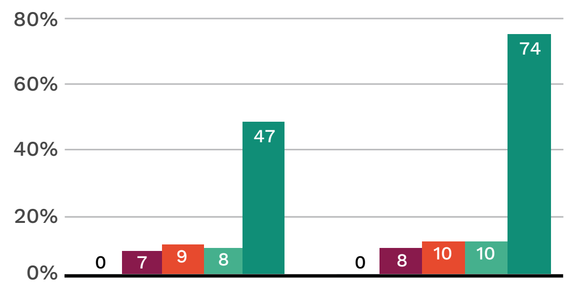
*Sustainable intensification technology and practices are projected to substantially increase yield in Brazilian soy production.*

Business as Usual | Modest-Forecast Policy | Modest-Coordinated Policy | Ambitious-Societal Transformation | Ambitious-Innovation

**Projected percentage change in Brazilian soy yield relative to 2020**




**Projected percentage change in Brazilian cropland use intensity relative to 2020**




**In absolute values** (tDM/ha)

| | Business as Usual | Modest-Forecast Policy | Modest-Coordinated Policy | Ambitious-Societal Transform-ation | Ambitious-Innovation |
|---|---|---|---|---|---|
| **2030** | 4.14 | 4.50 | 4.51 | 4.44 | 6.07 |
| **2050** | 4.47 | 4.57 | 4.70 | 4.64 | 7.36 |

**In absolute values** (Index)

| | Business as Usual | Modest-Forecast Policy | Modest-Coordinated Policy | Ambitious-Societal Transform-ation | Ambitious-Innovation |
|---|---|---|---|---|---|
| **2030** | 2.14 | 2.29 | 2.32 | 2.31 | 3.14 |
| **2050** | 2.14 | 2.32 | 2.35 | 2.34 | 3.73 |

Source: Authors' economic modeling (MAgPIE) results

Notes: For land use intensity details, see Dietrich et al (2012).[84]

**Brazilian soy cropland use intensity increase:**

Across 2°C and 1.5°C transition scenarios, cropland use intensity would rise between 8 and 74 percent

**Brazilian soy yield increase:**

Across 2°C and 1.5°C transition scenarios, Brazilian soy yield would increase between 14 and 84 percent

## Trend 3. Yield Improvements

As business models reliant on high land use and deforestation become less feasible, soy producers can adapt by prioritizing sustainable productivity investments and process improvements to boost the yield on existing land.

As land becomes more valuable, soy farmers across Brazil will increasingly lean into technology and practices that improve the efficiency of production on existing land to reduce costs. The sustainable intensification of production has already proven to be an important factor that partly offsets the growing demand for land driven by the boom in soy and maize exports, primarily to China.

Brazilian soy producers have a range of opportunities to increase efficiency and are experienced in adapting to meet changing market conditions and challenges. Continued development of low-cost, high-yield farming technologies and improved management practices will increase the volume of soy that can be produced per hectare of farmland, thus reducing the amount of land required for a similar production level.

Projections across transition scenarios show that staple export commodities in Brazil, including soy, maize and beef, are projected to perform in higher yields through sustainably intensified production and high technological advances, especially under the Ambitious-Innovation scenario. The low-cost yield-enhancing technology and advanced management practices assumed in this scenario would result in intensive cropland use and the highest yield growth, 84 percent by 2050, at the lowest cost (Figure 5). These practices would stem from increased research and development spending, which could lead to improvements in genetics, management practices, equipment and much more.

Under the Ambitious-Societal Transformation and Modest scenarios, including the IPR-aligned Forecast Policy scenario and the Coordinated Policy scenario, cropland intensity would increase between 8 percent and 10 percent over the same time period. While these efficiency improvements would still outpace Business as Usual, they would not benefit from low-cost investment at the same rate as that of the Ambitious-Innovation scenario.

**Brazilian soy production fluctuation:**

*Across 2°C and 1.5°C transition scenarios, Brazilian soy production would change between a decline of 13 percent to an increase of 17 percent*

## Trend 4. Modest Production Growth

Production increases are supported by the implementation of low-cost, yield-enhancing technology and sustainable management practices.

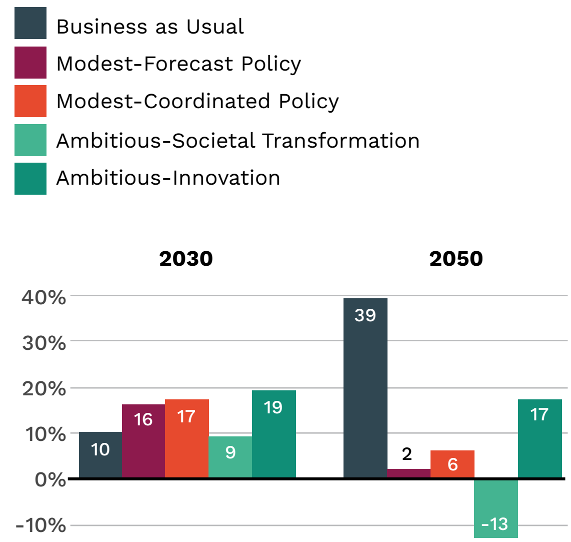
Affordable yield-enhancing technology in the Ambitious-Innovation scenario would enable Brazilian farmers to produce low-cost and low-emission soy, allowing the sector to maintain international cost competitiveness and profitability under climate transitions. The implementation of low-cost technological innovation would require collaboration across stakeholder groups to ensure the availability of financing and access to technology, as well as international technology transfers. This innovation-centric transition provides an example of how Brazil's soy sector could lean into an ambitious climate change response while still prioritizing yields, profitability and market share gains.

The 17 percent increase in production by 2050 projected under the Ambitious-Innovation scenario would far outpace the 13 percent production decline projected under the Ambitious-Societal Transformation over the same time period. Both scenarios reflect climate transitions aligned with limiting global warming to 1.5°C, but the pathways to get there have some significant differences around innovation, land costs and demand for ruminant meat, a major market for soy producers (Figure 6).

FIGURE 6.

### PROJECTED PERCENTAGE CHANGE IN BRAZILIAN SOY PRODUCTION RELATIVE TO 2020

*Ambitious climate policies have the potential to significantly constrain production without low-cost technology adoption.*




**In absolute values** (MMT DM/yr)

| | Business as Usual | Modest-Forecast Policy | Modest-Coordinated Policy | Ambitious-Societal Transform-ation | Ambitious-Innovation |
|---|---|---|---|---|---|
| **2030** | 93 | 98 | 99 | 92 | 101 |
| **2050** | 118 | 86 | 90 | 74 | 99 |

Source: Authors' economic modeling (MAgPIE) results.

Finally, the Ambitious-Innovation scenario would enable the Brazilian soy sector to maintain production levels even higher than projected across both Modest scenarios, despite much stronger environmental constraints. The Modest-Forecast Policy and the Modest-Coordinated Policy scenarios would see increases in production by 2 percent and 6 percent, respectively, higher than the Ambitious-Societal Transformation scenario but still significantly lower than in Business as Usual. If financing for affordable technological efficiency improvements were more widely available, Brazilian soy producers would be more resilient to these downward pressures on production.

## Trend 5. Accelerating Investment

**Agricultural capital investment increase:**

Across 2°C and 1.5°C transition scenarios, agricultural capital investment would increase between 88 and 133 percent

Investment in capital goods, land, advanced technology adoption and improved management practices could increase production efficiency.

Although climate transitions present considerable risks, they also present opportunities. Sustainable and transparent producers whose business models are not dependent on deforestation or the destruction of native vegetation for expansion are likely to be perceived as less risky as a result of heightened access to international markets and better resilience to climate transition risks, thus increasing access to affordable capital for yield improvements.

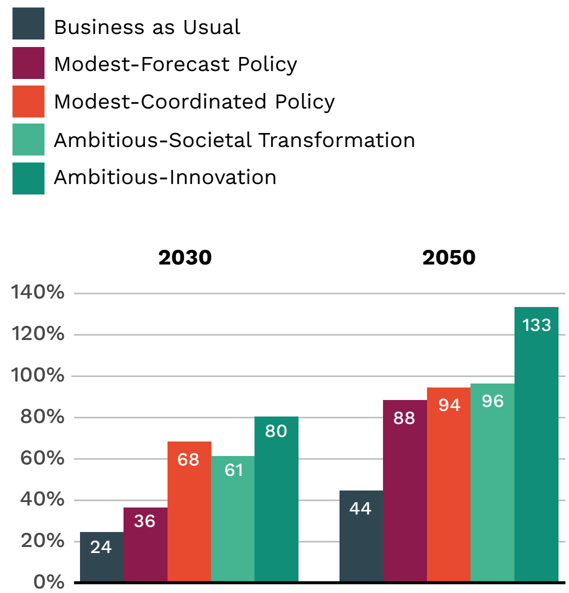
Across all transition scenarios, investment in capital goods, land, advanced technology adoption and improved management practices would enhance sustainable land use intensification for both cropland and pasture compared to Business as Usual, therefore increasing production efficiency. However, scaling up financing is an essential component of achieving the sustainable yield improvements needed to build resilience to transition risks.

Due to the availability of low-cost technological change in the Ambitious-Innovation scenario, agricultural spending is projected to increase by 133 percent by 2050. Capital investment would still outpace Business as Usual across the Ambitious-Societal Transformation, Modest-Forecast Policy and Modest-Coordinated Policy scenarios with 96 percent, 94 percent and 88 percent increases, respectively, between 2020 and 2050. Continued public and private efforts to increase the availability of financing linked to sustainable practices would increase the resilience of producers across climate transition scenarios. This is especially noteworthy, as investments can build resilience to both physical and transition risks (Figure 7).

FIGURE 7.

### PROJECTED PERCENTAGE CHANGE IN CAPITAL INVESTMENT IN BRAZILIAN AGRICULTURE RELATIVE TO 2020

*Significant financing is required to enable projected yield improvements across all transition scenarios.*




**In absolute values** (Billion USD)

| | Business as Usual | Modest-Forecast Policy | Modest-Coordinated Policy | Ambitious-Societal Transform-ation | Ambitious-Innovation |
|---|---|---|---|---|---|
| **2030** | 104 | 114 | 141 | 135 | 151 |
| **2050** | 120 | 157 | 163 | 164 | 195 |

Source: Authors' economic modeling (MAgPIE) results

Notes: The capital investment presented in the figure represents the aggregated net investment for all agricultural sectors in Brazil. This figure provides an indication of capital investment under climate transition scenarios across agricultural sectors and does not specify the soy sector.

**Brazilian soy producer price decrease:**

Across 2°C and 1.5°C transition scenarios, producers would see soy prices decline between 10 and 28 percent

## Trend 6. Soy Price Declines

Producer prices could decrease due to changing soy demand and lower production costs driven by technological innovation.

Higher financial mobilization and policy support for research and development investments across scenarios would reduce production costs and translate to lower producer prices. The high rate of technological change under the Ambitious-Innovation scenario would enable the highest production growth with the lowest costs and land requirements, resulting in a 28 percent decline in soy producer prices by 2050 (Figure 8).

Production (i.e., supply) and demand balance are also key drivers of price. Producer prices would drop only 10 percent in the Ambitious-Social Transportation scenario, which projects the lowest production and demand volumes. Meanwhile, the Modest-Forecast Policy and Modest-Coordinated scenarios project a 15 percent and 16 percent decline in producer prices, respectively.

Although the cattle sector is likely to see higher prices for deforestation-free, low-emission beef, this trend is less pronounced in the soy sector, partially because the majority of soy products are not directly consumed, leaving producers with less bargaining power in price setting across the supply chain.[55] However, soy producers that do not rely on deforestation or land degradation to grow will receive greater access to international markets and potentially more favorable financing as a result of lower climate transition risks.

**Brazilian soy demand fluctuation:**

Across 2°C and 1.5°C transition scenarios, global soy demand would change between a decline of 4 percent and an increase of 14 percent while domestic Brazilian soy demand would reduce between 1 and 14 percent

## Trend 7: Consumer Preference Changes

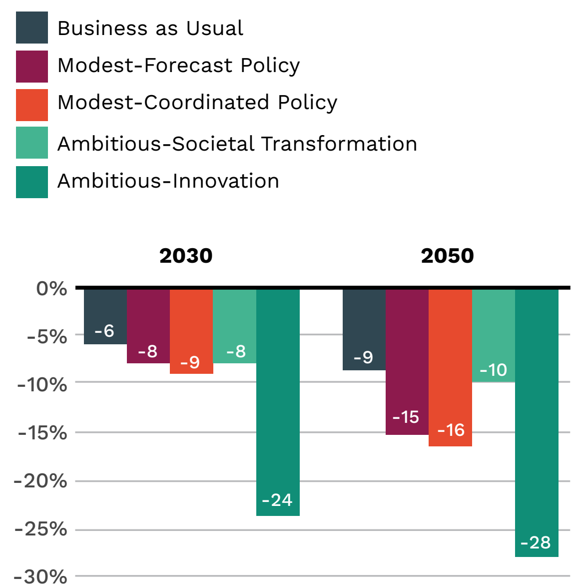
The demand for feedstocks would decrease under transition scenarios, but the diverse range of downstream soy applications will offer some resilience in international markets.

Lower per capita consumption of ruminant meat, either as a result of financial pressures, shifting consumer preferences or potential indirect policy implications, could affect the overall demand for animal-feed, which is currently the primary use of soy. These dietary shifts are most pronounced under the Ambitious-Societal Transformation scenario, with a 4 percent decline in global demand for soy by 2050 (Figure 9).

FIGURE 8.

### PROJECTED PERCENTAGE CHANGE IN BRAZILIAN SOY PRODUCER PRICES RELATIVE TO 2020

*Decreases in production costs and supply and demand dynamics would decrease the producer price of soy across transition scenarios.*



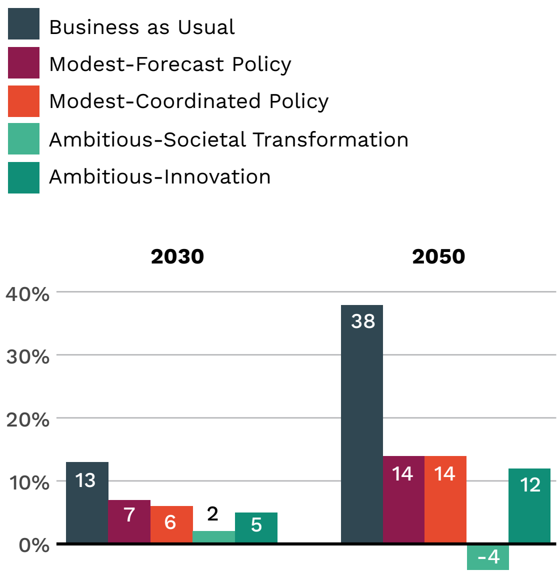

Source: Authors' economic modeling (MAgPIE) results

Although the Business as Usual scenario would experience the highest rise in global demand at 38 percent by 2050, the remaining transition scenarios would still see global soy demand increase between 12 percent and 14 percent. In this way, soy supply chains are more resilient to climate transition risks than ruminant meat because of the wide variety of downstream applications for soy products. For example, soy is used in the production of biofuels, plant-based protein products and as feed for non-ruminant meat livestock, markets that are expected to increase demand for soy under climate transitions. Proactive soy supply chains will be prepared to quickly adapt to new market segments and protect market share under climate transitions.

FIGURE 9.

### PROJECTED PERCENTAGE CHANGE IN GLOBAL SOY DEMAND RELATIVE TO 2020

*Diet shifts projected under climate transitions could decrease demand for feedstocks, partially offset by the growing demand for alternative proteins and biofuels.*




**In absolute values** (MMT DM/yr)

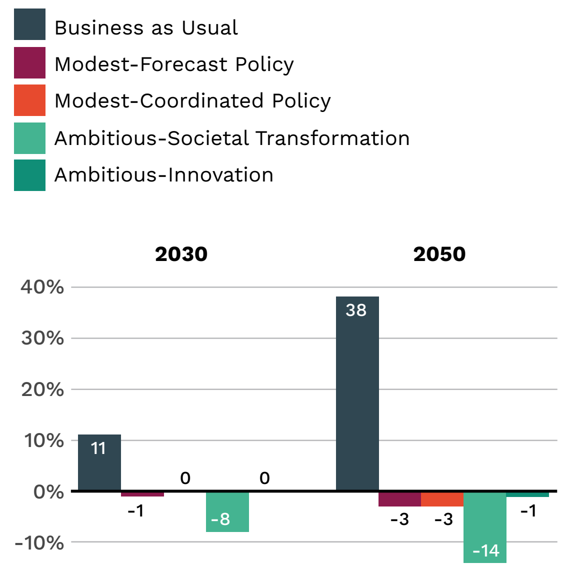
| | Business as Usual | Modest-Forecast Policy | Modest-Coordinated Policy | Ambitious-Societal Transformation | Ambitious-Innovation |
|---|---|---|---|---|---|
| **2030** | 350 | 330 | 329 | 315 | 326 |
| **2050** | 428 | 353 | 354 | 298 | 348 |

Source: Authors' economic modeling (MAgPIE) results

FIGURE 10

### PROJECTED PERCENTAGE CHANGE IN DOMESTIC BRAZILIAN SOY DEMAND RELATIVE TO 2020

*Diet shifts and softer producer price declines would cause the most significant demand reductions in the Societal-Transformation scenario.*




**In absolute values** (MMT DM/yr)

| | Business as Usual | Modest-Forecast Policy | Modest-Coordinated Policy | Ambitious-Societal Transformation | Ambitious-Innovation |
|---|---|---|---|---|---|
| **2030** | 42 | 38 | 38 | 35 | 38 |
| **2050** | 52 | 37 | 37 | 32 | 37 |

Source: Authors' economic modeling (MAgPIE) results

Proactive soy supply chains will be prepared to quickly adapt to new market segments and protect market share under climate transitions.

Consumer preference changes expected under climate transitions are expected to be felt more heavily in the domestic Brazilian market as a result of ruminant meat demand decreases of between 38 percent and 52 percent by 2050. Even under the Business as Usual scenario, demand for ruminant meat would drop by 9 percent.[56] Due to its role as a feedstock for domestic ruminant meat production, these demand shortfalls have significant implications for Brazilian soy demand domestically.

Between 2020 and 2050, domestic demand would stay relatively constant under

**Climate Transition Risk Scenario Analyzer**

**Available at:**
orbitas.finance/brazil-soy-tools

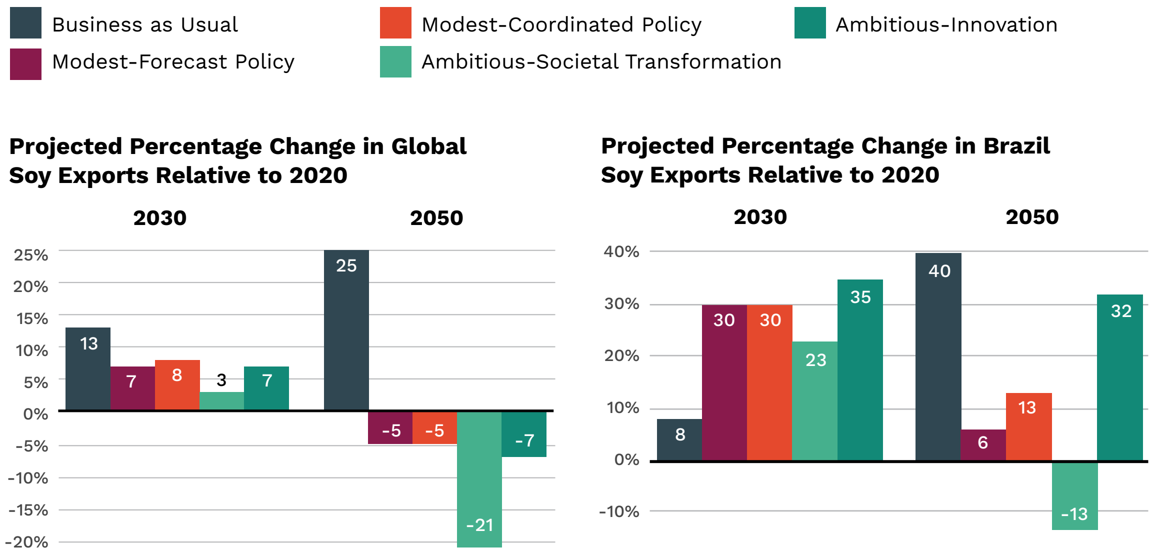
This interactive tool projects the evolution of the Brazilian soy sector under the climate transition scenarios analyzed here, which are used to assess the performance of representative farms. Users can leverage this tool to access information on:

- Demand, export, product prices, production and yield.
- Revenue, costs and profits for representative farms.
- GHG emissions and prices.

FIGURE 11.

## PROJECTED PERCENTAGE CHANGE IN SOY EXPORTS RELATIVE TO 2020

*The Brazilian soy sector can use innovation to increase exports, despite declining global soy trade.*




**In absolute values** (MMT DM/yr) — Global

| | Business as Usual | Modest-Forecast Policy | Modest-Coordinated Policy | Ambitious-Societal Transform-ation | Ambitious-Innovation |
|---|---|---|---|---|---|
| **2030** | 112 | 107 | 107 | 103 | 107 |
| **2050** | 125 | 95 | 95 | 79 | 93 |

Source: Authors' economic modeling (MAgPIE) results

**In absolute values** (MMT DM/yr) — Brazil

| | Business as Usual | Modest-Forecast Policy | Modest-Coordinated Policy | Ambitious-Societal Transform-ation | Ambitious-Innovation |
|---|---|---|---|---|---|
| **2030** | 51 | 61 | 61 | 58 | 63 |
| **2050** | 66 | 50 | 53 | 41 | 62 |

**Brazilian soy export fluctuation:**

Across 2°C and 1.5°C transition scenarios, Brazilian soy exports would change between a decline of 13 percent and a growth of 32 percent

the Ambitious-Innovation and both Modest scenarios, with reductions of 1 percent and 3 percent, respectively. However, the more significant diet shifts projected under the Societal Transformation scenario, combined with higher soy producer prices than other transition scenarios, would result in a 14 percent drop in demand over the same time period (Figure 10).

### Trend 8. Competitive Advantage in Exports

Brazil has the potential to grow its competitive advantage for deforestation-free, low-emission and high-yield soy under climate transitions, increasing exports despite a decline in global traded soy volumes.

Brazil's exports would largely be resilient to the global 5 to 21 percent drop in traded volumes of soy under transition scenarios (Figure 11). Brazilian soy would maintain competitive advantage with exports growing between 6 percent and 32 percent by 2050 under all scenarios except under the Ambitious-Societal Transformation scenario, which would experience a reduction of 13 percent due to the lower demand for feedstock resulting from changing consumer preferences.

However, access to export markets is dependent on implied deforestation-free, low-emission and high-yield soy advancements that would solidify Brazil's competitive advantage on the global stage. Efforts to improve the productivity of Brazilian soy farms would play a significant role in offsetting the high pressure on land under climate transition scenarios while meeting international demand for deforestation-free, low-emission soy at competitive prices.

# Assessing Farm-Level Resilience Through Financial Stress Testing

*Shocks to the price of soy could threaten the financial stability of all but the highest efficiency producers across Brazil, while transportation cost fluctuations could result in significant regional impacts.*

## Section 5

A substantial portion of Brazilian producers are already at high risk of experiencing financial loss.

The productivity and resilience of producers within Brazil's soy sector to economic shocks is a predictor of the sector's ability to withstand risks and seize opportunities across transition scenarios. These economic shocks can occur for many reasons.

However, soy commodity prices and transportation costs are particularly relevant, as they are both likely to be impacted directly under volatile climate transitions and are material to soy producers' profitability. Simulating shocks to each of these variables through stress testing can provide insight into the probability of regional profitability losses if Brazilian producers maintain their current levels of productivity in the face of shocks.[h]

The impact of short-term shocks on soy producers can be understood through the lens of a producer's probability of financial loss and the likelihood of costs exceeding revenue in a particular year.

### Chapter Highlights

Under current market conditions, a substantial portion of Brazilian producers are already at high risk of experiencing financial loss in a given year. When economic shocks are introduced, this risk is elevated, resulting in:

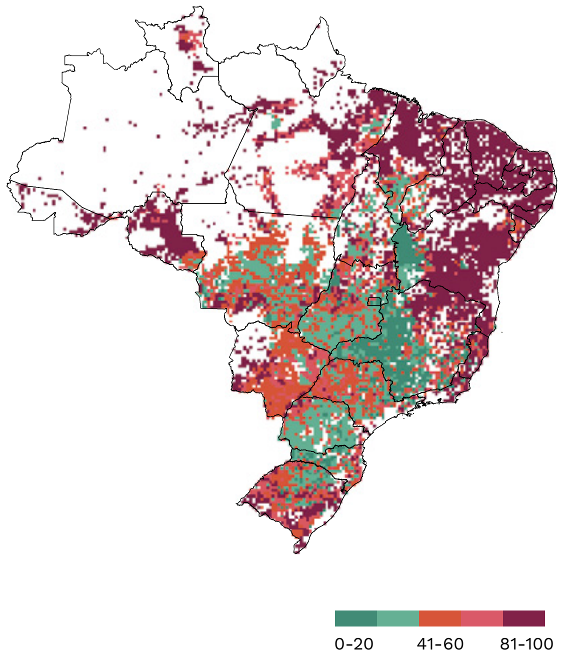
- Shrinking profits in all but the top performing representative production systems, mostly located in Minas Gerais, if soy prices decrease by 30 percent.
- A more uneven effect of a 100 percent transportation cost increase on producer performance, depending on distance to roads, demand centers, ports and processing facilities, with loss likelihood above 81 percent primarily contained to eastern Brazil.
- The majority of representative farms facing significant risk of financial loss and many of them encountering an over 60 percent likelihood that costs exceed revenues in the case of a combination of both transportation and soy price shocks.

[h] This analysis should be considered as a hypothetical, addressing a broad range of plausible near-term futures rather than a scenario-specific estimate. This highly indicative information cannot be used alone for making financial decisions.

FIGURE 12.

**LIKELIHOOD OF FINANCIAL LOSS IN CURRENT MARKET CONDITIONS**

*Proxy indicators are used to calculate the likelihood of financial loss projections.*



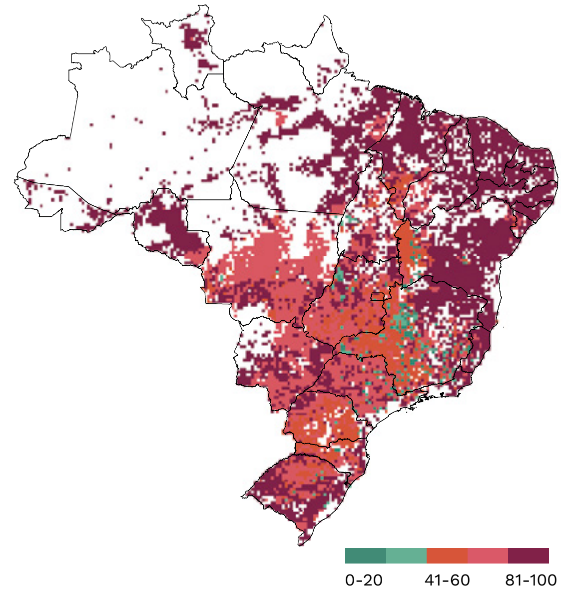

Source: Authors' spatial and financial modeling.

Notes: All datasets are shown at 0.2 × 0.2 degree spatial resolution (about 22 × 22 km at the equator). Empty regions on the map signify the absence of data or farms in that particular area.

FIGURE 13.

**LIKELIHOOD OF FINANCIAL LOSS WITH A 30 PERCENT SHOCK TO SOY PRICES**

*Proxy indicators are used to calculate the likelihood of financial loss projections*




Source: Authors' spatial and financial modeling.

Notes: All datasets are shown at 0.2 × 0.2 degree spatial resolution (about 22 × 22 km at the equator). Empty regions on the map signify the absence of data or farms in that particular area.

Decreasing soy prices by 30 percent makes it more likely that profits would shrink in all but the top-performing representative production systems.

Under current market conditions, a substantial portion of Brazilian producers are already at high risk of experiencing financial loss, especially among remote producers with low productivity and slim profit margins (Figure 12). Lower productivity production facilities, primarily located in states in the northeast of Brazil, currently face up to a 90 percent probability of financial loss.[i] These farms have the weakest ability to buffer potential market fluctuations and are the most susceptible to profitability losses. Producers in southern Brazil, however, are more resilient to financial losses due to more intensive farming practices and higher annual productivity.

When additional economic shocks are layered in, the most vulnerable farms would likely not have the resilience to maintain positive profitability. For example, decreasing soy prices by 30 percent makes it more likely that profits would shrink in all but the top-performing representative production systems found across portions of Minas Gerais (Figure 13).

Surrounding regions that previously had a relatively low profit loss probability, under 30 percent, would see that probability spike to between 61 and 80 percent. In fact, the majority of regions would now experience over 60 percent risk of financial loss, indicating that even the most productive farms could experience shortfalls in profit margins during price-related economic shocks.

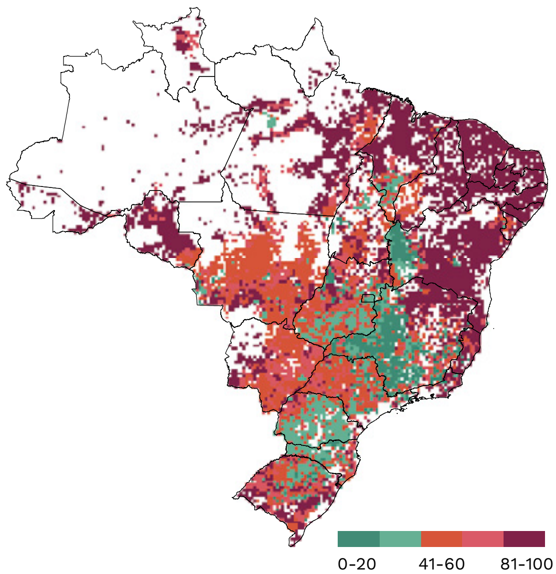
Further, a shock to transportation pricing would have a more uneven effect on producer performance depending on distance

[i] This outlook on a hypothetical average production facility representing lower productivity farms based on regional averages is not established as a profit forecast analysis.

FIGURE 14.

### LIKELIHOOD OF FINANCIAL LOSS WITH A 100 PERCENT SHOCK TO TRANSPORTATION COSTS

*Proxy indicators are used to calculate the likelihood of financial loss projections.*



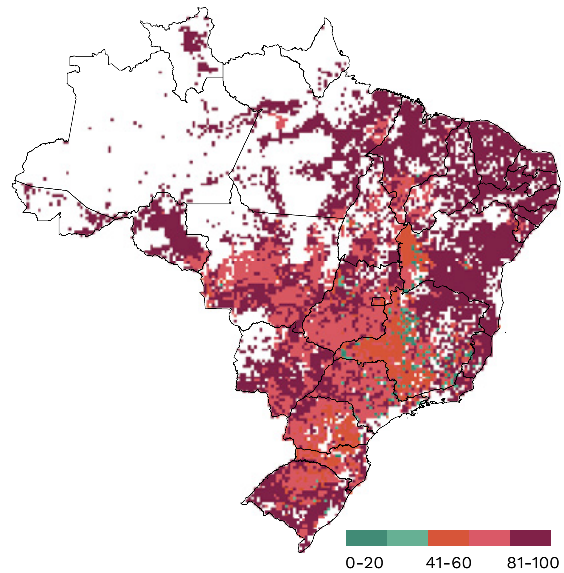

Source: Authors' spatial and financial modeling.

Notes: All datasets are shown at 0.2 × 0.2 degree spatial resolution (about 22 × 22 km at the equator). Empty regions on the map signify the absence of data or farms in that particular area.

FIGURE 15.

### LIKELIHOOD OF FINANCIAL LOSS WITH BOTH A 30 PERCENT SHOCK TO SOY PRICES AND A 100 PERCENT SHOCK TO TRANSPORTATION COSTS

*Proxy indicators are used to calculate the likelihood of financial loss projections.*




Source: Authors' spatial and financial modeling.

Notes: All datasets are shown at 0.2 × 0.2 degree spatial resolution (about 22 × 22 km at the equator). Empty regions on the map signify the absence of data or farms in that particular area.

to roads, demand centers, ports and processing facilities. Increasing transportation costs to key soy infrastructure with a 100 percent transportation price shock is less severe than a shock to soy prices, with loss likelihood above 81 percent primarily contained to eastern Brazil, while top-performing production systems located in the south would maintain a loss likelihood of less than 40 percent (Figure 14).

Farms with easy access to infrastructure and transportation costs that constitute a small proportion of total expenses would be largely resilient to this shock. However, transportation costs are extremely material in low-productivity and remote facilities, where this shock would be more deeply felt on financial statements.

A combination of both transportation and soy price shocks would put the majority of representative farms at significant risk for financial loss, with most producers expected to encounter an over 60 percent likelihood that costs exceed revenues (Figure 15). The key exceptions appear to be operations across limited portions of Minas Gerais, due to a variety of factors, including efficient farming techniques and proximity to port facilities.

A combination of both transportation and soy price shocks would put the majority of representative farms at significant risk for financial loss.

**Financial Stress Testing Tool**

**Available at:**
orbitas.finance/brazil-soy-tools

This interactive tool assesses the resilience of representative farms to climate transitions through stress testing. It evaluates the probability of financial losses in Brazilian soy production based on the hypothetical economic shocks that could impact yield, transportation costs and commodity pricing. These economic shocks are derived from climate transition projections and historical price and cost fluctuations.

# Evaluating Existing Farm Profitability Through the Lens of Climate Transition Scenarios

## Section 6

*If Brazilian soy farmers do not take action to prepare for climate transitions, profitability shortfalls may occur due to growing land prices, emissions costs, declining soy producer prices and more.*

Integrating costs and revenues projected under climate transitions into the financial statements of Brazilian soy producers operating today shines light on how existing soy farms would perform financially if no action is taken to adapt.

Economic scenario analysis is essential to understanding how the conditions affecting the Brazilian soy sector will change as climate transitions intensify, but how would climate transitions impact farmers that do not adapt to these new conditions? If soy producers were to continue operating at current productivity levels, how would they be affected by increases in land rent costs, emerging GHG emission pricing, volatile commodity prices and more?

Integrating costs and revenues projected under climate transitions into the financial statements of Brazilian soy producers operating today shines light on how existing soy farms would perform financially if no action is taken to adapt. By evaluating representative production types' — and by extension an investment portfolio's — vulnerability to these risks across climate transition scenarios, investors can gain insight into how producers can mitigate risks.

Representative farms from three major soy producing regions, Parana, Rio Grande do Sul and Mato Grosso, cover a range of practices from low technology techniques to intensive systems utilizing a range of precision agriculture technologies. These farms can be categorized into four production types: High Performance, Upper Medium Performance, Lower Medium Performance and Low Performance (Figure 16).[57 58]

These representative farms span (i) different levels of soy yield; (ii) different second harvest crops, including maize and wheat; (iii) different cost structures, including share of land rent, labor, machinery, fertilizer, transport costs, administrative expenses and more; and (iv) different levels of performance measured by operational profit.

### Chapter Highlights

The combination of yields, commodity prices, GHG prices and land prices will materially change the financial performance of soy producers as climate transitions intensify and should not be overlooked by stakeholders across the industry. Based on stress testing of representative farms, land ownership and the implementation of innovative technology to increase yields and reduce the emission intensity of production highlight clear pathways to mitigate these negative impacts and maintain the resilience of profitability.

FIGURE 16.

**TYPES OF REPRESENTATIVE FARMS BY PRODUCTIVITY LEVEL**

*Representative farms in the soy producing states of Parana, Rio Grande do Sul and Mato Grosso span a wide range of productivity assumptions*

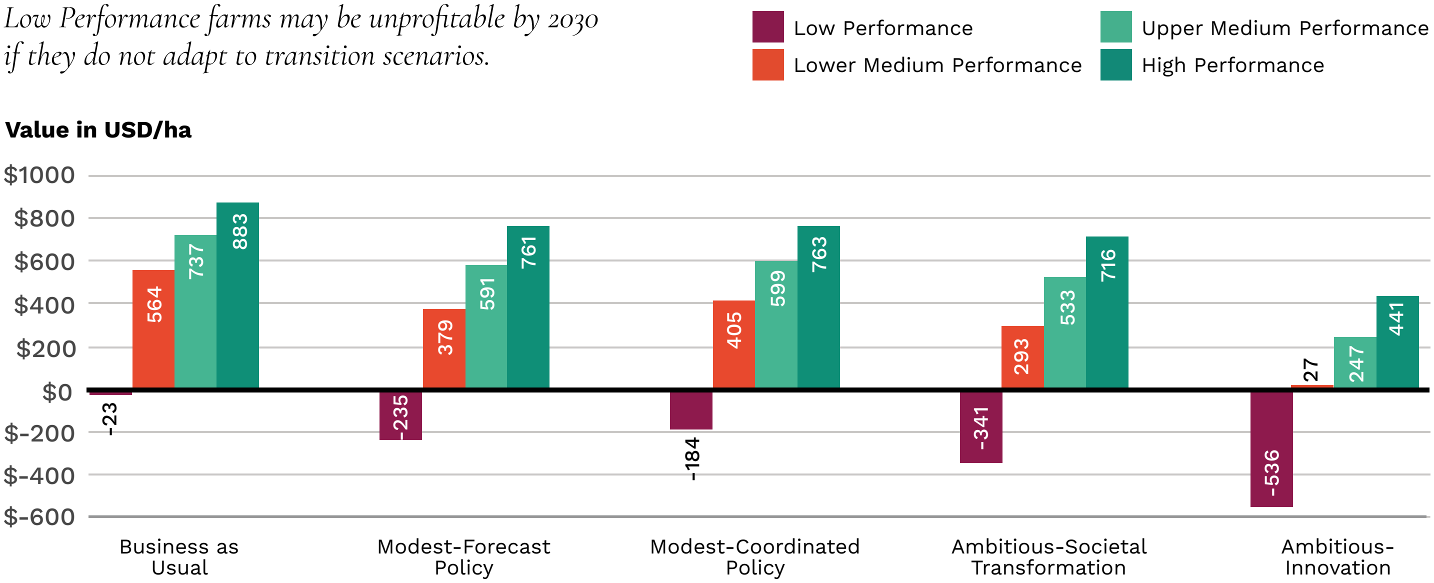
| Representative Farm Type | Characteristics of Representative Producers |
|---|---|
| High Performance | High profitability farm in Mato Grosso |
| Upper Medium Performance | Relatively profitable farm in Mato Grosso |
| Lower Medium Performance | Median profitability farm in Rio Grande do Sul |
| Low Performance | Median profitability farm in Parana |

Source: Conab, USDA.[85]

FIGURE 17.

## 2030 PROFITABILITY BY FARM SYSTEM ACROSS SCENARIOS

*Low Performance farms may be unprofitable by 2030 if they do not adapt to transition scenarios.*




**Differences relative to 2020 (USD/ha)**

| | Business as Usual | Modest-Forecast Policy | Modest-Coordinated Policy | Ambitious-Societal Transformation | Ambitious-Innovation |
|---|---|---|---|---|---|
| Low Performance | -44 | -256 | -205 | -362 | -557 |
| Lower Medium Performance | -17 | -202 | -176 | -288 | -554 |
| Upper Medium Performance | -13 | -159 | -150 | -217 | -503 |
| High Performance | -11 | -132 | -130 | -177 | -453 |

Source: Authors' economic and financial modeling.

*If producers do not take action to prepare for the climate transitions analyzed in section 4, Low Performance farms are likely to experience financial losses before 2030.*

### 2030 Profitability Expectations for Representative Farms That Do Not Adapt To Climate Transitions

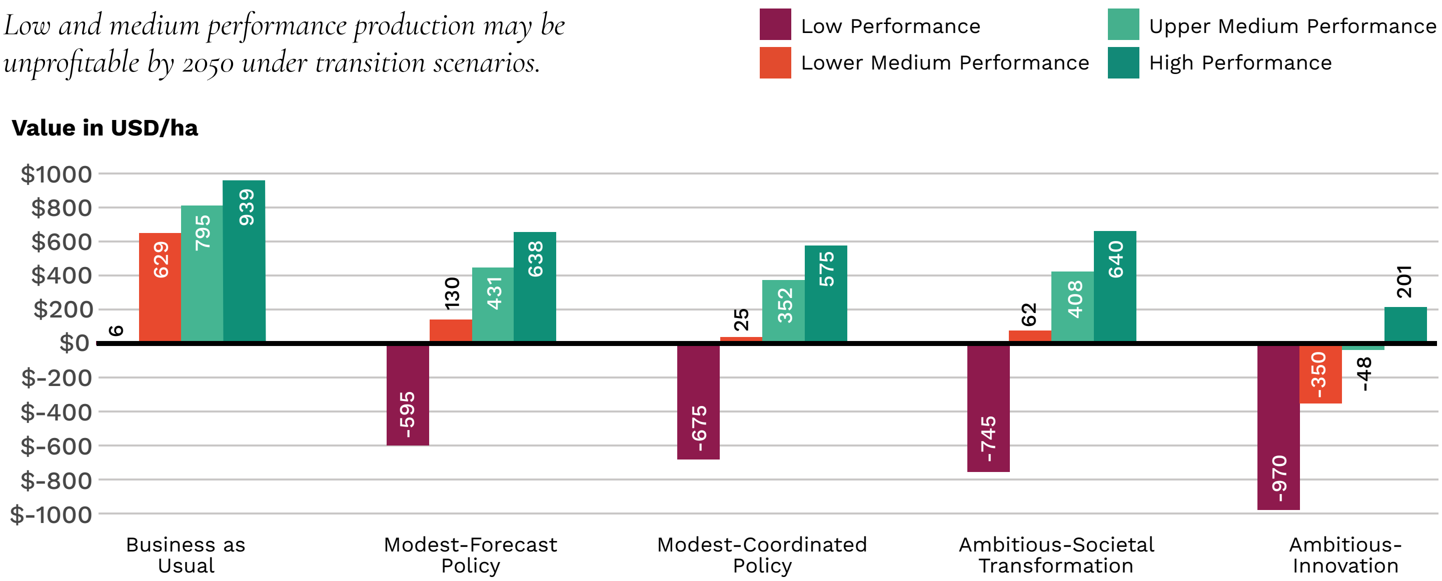
If producers do not take action to prepare for the climate transitions analyzed in section 4, Low Performance farms are likely to experience financial losses before 2030 (Figure 17).

As land availability decreases, high rent costs and competition for land from the bioeconomy are likely to challenge the business models of these farms. Furthermore, emissions payments, lower soy producer prices and declining domestic Brazilian demand would reduce the profitability of all representative farms compared to the Business as Usual scenario.

FIGURE 18.

## 2050 PROFITABILITY BY FARM SYSTEM ACROSS SCENARIOS

*Low and medium performance production may be unprofitable by 2050 under transition scenarios.*




**Differences relative to 2020** (USD/ha)

| | Business as Usual | Modest-Forecast Policy | Modest-Coordinated Policy | Ambitious-Societal Transformation | Ambitious-Innovation |
|---|---|---|---|---|---|
| Low Performance | -16 | -617 | -697 | -767 | -992 |
| Lower Medium Performance | 48 | -451 | -556 | -519 | -931 |
| Upper Medium Performance | 45 | -319 | -397 | -341 | -798 |
| High Performance | 46 | -255 | -318 | -253 | -692 |

Source: Authors' economic and financial modeling.

*Only today's High Performance farms would maintain high profitability across scenarios by 2050.*

### 2050 Profitability Expectations for Representative Farms That Do Not Adapt To Climate Transitions

In the age of climate transition risks, only today's High Performance farms would maintain high profitability across scenarios by 2050. High Performance farms would achieve the highest profitability, USD 640 per hectare, under the Ambitious-Social Transformation scenario in 2050, with only a USD 253 profitability shortfall by 2050 relative to 2020. Conversely, the Ambitious-Innovation scenario projects the lowest soy price, a 28 percent decrease by 2050, which would result in the lowest profitability for market laggards across all farm types, with only High Performance farms maintaining positive profitability of USD 201 per hectare (Figure 18).

Without process and technology change, Low Performance farms are likely to experience significant financial losses across all transition scenarios, with profitability dropping between USD 617 and USD 992 below 2020 levels by 2050. While Upper and Lower Medium Performance farms would likely remain profitable under both Modest scenarios and Ambitious-Societal Transformation scenarios by 2050, they would experience losses under the Ambitious-Innovation scenario if they do not take action to prepare for climate transitions.

> Farmers would have the greatest access to climate transition opportunities under the Ambitious-Innovation scenario, with low-cost technological advancements widely available.

## Opportunities Through Technology Investments During Climate Transitions

Importantly, farmers would have the greatest access to climate transition opportunities under the Ambitious-Innovation scenario, with low-cost technological advancements widely available, giving producers a clear pathway to mitigate risks. As producers adopt high-efficiency production methods and reduce the emission intensity of production, those left behind will likely have operating costs higher than those of competitors and will be unable to compete.

For producers who take action to increase efficiency and invest in innovative technology, profitability would increase through higher-yield operating practices and more efficient fertilizer use. These investments would have additional financial benefits, as technology can reduce the emission intensity of production, reducing the payments producers face as GHG prices increase.

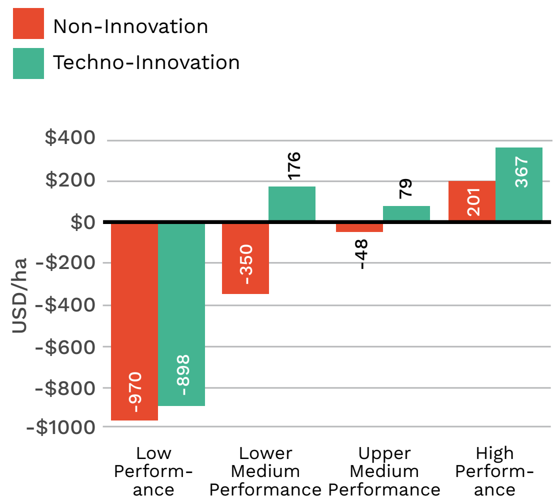
If these actions were taken by producers under the Ambitious-Innovation scenario, the financial profitability per hectare of Low Performance, Lower Medium Performance and Upper Medium Performance farms would improve by USD 72, USD 526 and USD 127, respectively (Figure 19).[j]

These technology investments would increase resilience for both Medium Performance farms, as profitability becomes positive across climate transition scenarios. Low Performance farms, however, would still struggle with profitability. In this stress test, the advantages derived from adopting technology would not be sufficient to offset financial losses related to performance unless significant changes are made before 2050. In order to increase resilience by 2050, Low Performance farms would need to invest in technological advancements at a higher rate than higher performing competitors.

FIGURE 19.

### THE EFFECT OF TECHNOLOGICAL INNOVATION ON PROFITABILITY UNDER THE AMBITIOUS-INNOVATION SCENARIO IN 2050

*High Performance production can increase profitability by 83 percent by 2050 under the Ambitious-Innovation scenario.*




Source: Authors' economic and financial modeling.

Notes: This figure shows the effect of technological innovation on the estimated profit for all farm types in 2050 under the Ambitious-Innovation scenario. "Non-Innovation" means that no innovative technology is implemented, resulting in no associated cost and no yield increase. "Techno-Innovation" means the adoption of innovative technology that requires investments but leads to higher yields and improved nitrogen use efficiency.

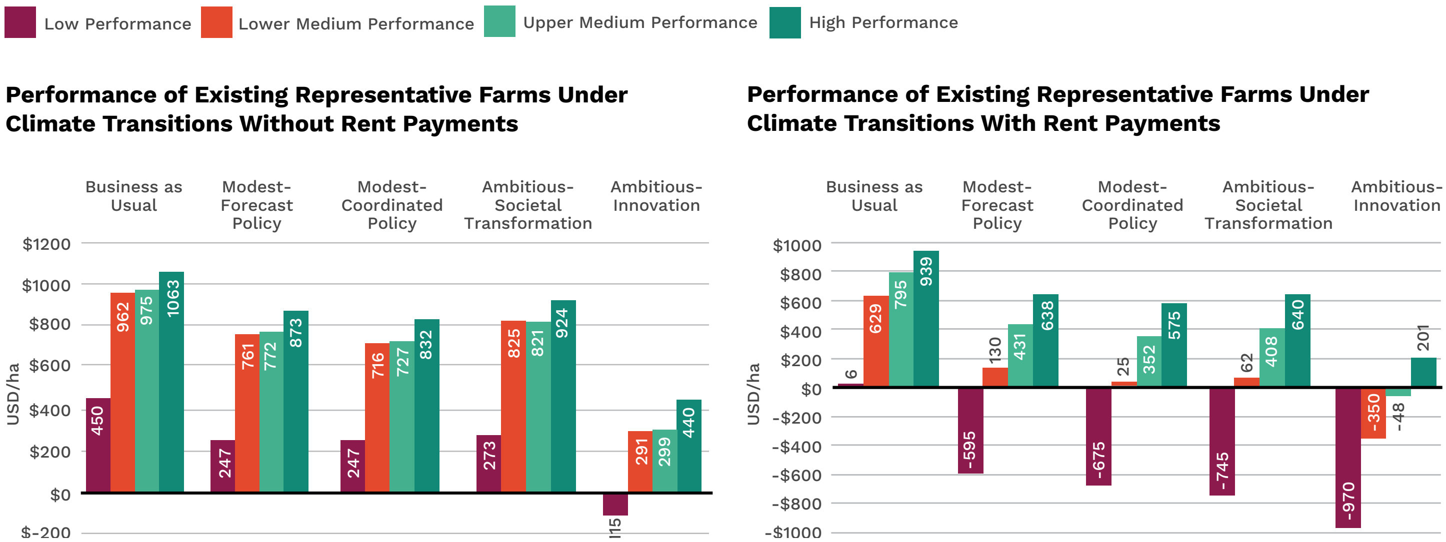
When investments in technology improvements, infrastructure and capacity are introduced into the financial projections of High Performance farms, profitability would increase by 83 percent compared to the same farm without technological innovation. These investments would drive material changes in synthetic nitrogen fertilizer usage, cropland area needs and yields.

[j] In this example, the cost of investing and implementing yield-enhancing innovative technology under the Ambitious-Innovation scenario is assumed to be USD 500 per hectare each year on average. However, it is important to note this cost is the same across all types of soy producers in Brazil. The variation in costs across producers with different performance levels and different locations are not taken into account, making these estimates conservative.

FIGURE 20.

## LAND RENT PAYMENT IMPACTS ON PROFITABILITY OF BRAZILIAN SOY FARMS BY 2050

*Without major innovation and efficiency improvements, rent payments could make Low Performance farms unprofitable by 2050*




Source: Authors' economic and financial modeling.

> Producers who own land and therefore do not have land rents or related loan payments are significantly more resilient to climate transitions than those with these payments.

### Opportunities Through Land Ownership Under Climate Transitions

Brazilian government actions to meet domestic and international climate commitments, coupled with the growing competition for agricultural land from the bioeconomy, will increase land prices across transition scenarios. Low Performance farms with the least capacity to absorb these rising land rent prices are likely to sustain financial losses across transition scenarios by 2050, as shown in Figure 20. When land rent payments are removed from profitability calculations, Low Performance farms could become profitable across both Modest scenarios and the Ambitious-Societal Transformation scenario by 2050. In the Forecast Policy scenario, for example, Low Performance farms increase profitability by USD 842 solely by removing land rent payments in 2050.

In the Ambitious-Societal Transformation scenario, Low Performance farms would increase profitability by USD 1018 without rent payments. Although owning land may not shield Low Performance farms from losses under the Ambitious-Innovation scenario, the losses per hectare are expected to decline from USD 970 to USD 115. These projections point to significant opportunities for Low Performance farms to increase profitability, especially if land ownership is combined with actions like adopting innovative technology to increase yields.

Opportunities are not limited to Low Performance farms. Lower and Upper Medium Performance farms without rent payments would experience significant competitive advantage by 2050. Lower and Upper Medium Performance farmers who are exempt from land rent payments would experience an increased profitability of USD 641 and USD 347, respectively, by 2050, while farms with rent payments would likely experience financial losses under the Ambitious-Innovation scenario.

As such, producers who own land and therefore do not have land rents or related loan payments are significantly more resilient to climate transitions than those with these payments. The potential for future land price increases presents a material risk to the majority of renters, making rents, loan payments and land ownership important components to be considered for future financial success in the Brazilian soy sector. Establishing pathways toward land ownership before the anticipated surge in land prices could potentially help mitigate this

As of 2016, land leases and sharecropping contracts were used on less than four percent of Brazilian farmland, compared to 38 percent in the United States and 33 percent in Europe.


risk while giving producers the financial flexibility to invest in sustainable yield enhancing and emission reduction initiatives. As of 2016, land leases and sharecropping contracts were used on less than four percent of Brazilian farmland, compared to 38 percent in the United States and 33 percent in Europe.[59] If this trend continues, Brazilian farmers may have some resilience to increasing land rent payments in the future. Maintaining these pathways is particularly important since 53 percent of agricultural land is occupied by the top 1.5 percent of rural landowners in Brazil.[60] Meanwhile, family farms produce an estimated 70 percent of food consumed in Brazil but occupy only 25 percent of the land.[61]

# Opportunities for Growing Profitability in the Brazilian Soy Sector

**Section 7**

*Brazilian soy farmers can proactively adopt technology and management solutions that increase financial resilience to climate transitions and diversify revenue streams.*

Proactive mitigation of these risks can reduce financial losses while market leaders may even experience financial gains through leaning into climate transition opportunities.

The risks presented by climate transitions for the Brazilian soy sector are clear and material. Even so, proactive mitigation of these risks can reduce financial losses while market leaders may even experience financial gains through leaning into climate transition opportunities, including (i) adopting technological advancements and sustainable agricultural practices to increase efficiency; (ii) reducing the emission intensity of production to drive down operating costs; (iii) mitigating exposure to economic shocks; (iv) lowering land rental payments; (v) adapting to meet demand from growing market segments; and (vi) supplemental income from the bioeconomy.

Land use efficiency improvements, which involve increasing crop yield per hectare of land, can create higher and more resilient profits capable of weathering a range of climate transition-related economic shocks. Producers with more efficient land use practices are more likely to achieve profit optimization than their peers. A wide range of technologies are already available to market leaders in the soy industry seeking to maximize profitability under climate transitions, including precision agriculture, seed selection and farm automation and robotics. Research and development will only enhance this trend as climate transition opportunities materialize.

Producers can use efficiency-enhancements to achieve cost reductions on fertilizer utilization, pesticide application and fuel usage while also increasing yields and improving resilience to increases in GHG emissions costs as climate transitions intensify.[62] This is particularly relevant as more governments are considering or adopting GHG emission taxes, cap and trade programs or emissions trading schemes. Producers who reduce their reliance on high emission inputs and processes will mitigate the risks associated with emission-intensive production, particularly regarding high carbon dioxide emissions from fuel and $N_2O$ emissions from fertilizer application.

Lower cost sustainable agriculture practices like no-till farming, cover crop rotation and integrated pest management can also significantly improve yields for producers without access to low-cost financing. Importantly, yield enhancements can reduce the cost per unit of output, especially as land becomes more expensive. Lowering production costs per unit will create a significant competitive advantage and allow producers to maintain positive margins, even as soy prices are projected to decline between 10 and 28 percent across climate transition scenarios by 2050.

In addition to production cost reductions from efficiency enhancements and GHG emission reductions, soy producers can also mitigate exposure to short-term economic shocks through farmer-organized storage and fixed contracts. Storage, along with fixed-cost agreements, can help protect against temporary economic shocks related to transportation costs during short-term surges in fuel prices. For farmers located away from demand centers, processing facilities and port facilities, however, transportation costs will likely continue to outpace competitors and create higher incentives to adapt to climate transitions. Similarly, soy producers can consider harvest insurance or fixed-price agreements to hedge against temporary soy producer price declines caused by climate transition-driven economic shocks. Adoption has accelerated in recent years, with soy representing 30 percent of insurance policies and over half of

Despite the upfront investments required in many climate transition adaptation strategies, they are projected to achieve significant gains in profit generation in the long run.

the total disbursed premiums in 2018.[63]

Producers with access to financing can consider taking steps toward land ownership, although this option will be limited to those with financing. Land rental payments are expected to make up a higher proportion of production costs, as conservation and competition from the bioeconomy decrease land available for agriculture. Opting to purchase land instead of renting it would provide resilience to farmers, especially when land prices appreciate at a rate surpassing the interest rates on stable loan payments. Enhancing pathways to purchase and retain land will require coordination among stakeholder groups across the Brazilian soy sector.

Despite the upfront investments required in many climate transition adaptation strategies, they are projected to achieve significant gains in profit generation in the long run. A comprehensive approach that combines land use efficiency improvements, cost reduction strategies and prudent financial management is essential for soy producers to thrive in a dynamic market.

Soy producers can also consider additional revenue streams to diversify income and increase resilience to profitability shortfalls. Agroforestry and non-timber forest products, producing multiple crops on existing land, integrated crop-livestock systems (iCLF) and receiving payments for conservation through carbon markets all represent opportunities for soy producers to enhance profitability and mitigate climate transition risks through diversification.

Soy markets face significant uncertainty, but supply chains that can quickly pivot to meet growing demand from emerging market segments will have access to more opportunities under climate transitions than competitors. Sustainable aviation fuels, plant-based proteins and feedstock for non-ruminant meat livestock represent opportunities as climate transitions intensify.

By proactively anticipating climate transition impacts and leaning into opportunities, even the least productive soy farmers could increase profitability. In order for the Brazilian soy sector to access the high productivity rates needed to maximize profitability under climate transitions, however, significant mobilization of financing is needed, especially for smallholder farmers.

# Market Leader Opportunities

## HIGH-EFFICIENCY TECHNOLOGY SOLUTIONS

Concerns around resource use, environmental impacts, and above all, financial security have pushed the adoption of data-enabled agriculture solutions in recent years. Led initially by large commercial players, market leaders have increasingly integrated precision agriculture practices, explored nascent robotics and farm automation technologies and prioritized the selection of seed varieties best accustomed to regional climate conditions.[64] While adoption rates vary between different regions and farm sizes, ensuring affordable access to data management systems and advanced equipment is a key component of farm profitability maximization strategies for market leaders across ambitious transition scenarios.

| | |
|---|---|
| **Precision Agriculture** | • One of the most notable high-efficiency solutions is the adoption of precision farming techniques, which leverage real-time data and sensor technology to monitor crop health and soil fertility.[65] This enables soy farmers to make informed decisions and optimize agricultural inputs, ultimately enhancing crop health and growth rates. Additionally, the integration of satellite-based geospatial technologies enables more efficient land management and reduces land degradation.[66] |
| **Farm Automation and Robotics** | • A developing opportunity for Brazilian farmers is the integration of robotics and automation in soy agriculture, which has grown in recent years and provides efficiency improvements, reduced labor costs and enhanced productivity for early adopters. Producers have made use of aerial drones for spraying, crop monitoring and farm management, while terrestrial drones are being evaluated for their ability to automate some weeding, planting and harvesting operations.[67] Despite the nascent nature of the market, producers across agricultural commodities have expressed interest in future opportunities. |
| **Seed Selection** | • Through careful genetic manipulation, plant breeders at the Brazilian Federal University of Lavras, the United States Department of Agriculture and Argentinean seed companies (e.g., Grupo Don Mario), work to enhance traits crucial for sustainable soy production (e.g., higher yielding varieties, phenotypic stability, disease resistance and drought tolerance).[68] [69] Seed selection represents a continuous improvement process that not only increases agricultural productivity but may also contribute to resource efficiency and resilience to evolving physical climate risks.[70] |

## SUSTAINABLE AGRICULTURE PRACTICES

Farm automation, precision agriculture and seed selection offer market leaders a range of options to improve agriculture efficiency. However, the cost associated with these developing technologies may restrict access to smallholder farms, renters and others without access to low-cost financing. For these reasons, the Brazilian Agricultural Research Corporation (Embrapa) also recommends adopting a range of practices aimed at achieving significant efficiency improvements, albeit at a lower cost than the most technologically advanced options.[71]

| | |
|---|---|
| **No-till Farming** | • Popularized in the 1970s as part of the 'sistema de plantio direto,' a system of conservation agriculture, no-till farming is practiced across 33 million hectares, which represents around half of Brazil's total cropland area.[72] This practice is a form of sustainable agriculture that encourages farmers to sow their crops in undisturbed soils.[73] Instead of plowing before each harvest, seeds are planted directly into untilled soil, leaving crop residues from the previous harvest on the surface. Reducing soil disturbance has been found to improve soil health, reduce soil erosion, conserve water and improve crop yields for soy by 27 percent on average.[74 75] |
| **Cover Crop Rotation** | • The second piece of the 'sistema de plantio direto' calls for year-round field cover achieved through the minimization of the interval between each of Brazil's three harvests. Grains, such as millet, black oat, sunn hemp and sorghum, are typically used as cover crops alongside soy. Reducing the window of barren soil has been found to protect against erosion, reduce pest outbreaks, improve off-season nutrient cycling and reduce the reliance on synthetic fertilizers and herbicides. |
| **Integrated Pest Management** | • Susceptibility to pests and fungus, most notably the Asian rust fungus called phakopsora pachvrhizi, remains a serious obstacle to soybean productivity. This can restrict the use of more productive farming strategies that emphasize producing multiple crops on the same land across growing seasons, due to the increased risk brought by shorter crop rotation intervals. Integrated pest management offers a more effective and economical option to traditional pest management, mitigating the spread of damage through proper monitoring and biological, mechanical and chemical control methods. Effective use can better manage pest populations while minimizing the growing reliance on synthetic pesticides and impacts to the environment. |

## ALTERNATIVE REVENUE STREAMS

Many soy producers far from the value chain and transportation infrastructure already experience a high probability of financial loss. With climate transition risks projected to exacerbate existing profitability gaps, individuals will need to be creative, finding ways to capitalize on a diverse range of alternative revenue streams in order to weather increasingly unpredictable markets, policies and growing conditions. These may take the form of diversifying products through agroforestry, double cropping, iCLF or receiving payments for conservation through growing carbon markets.

| | |
|---|---|
| **Agroforestry** | • Agroforestry systems and the sustainable management of non-timber forest products (NTFPs) can be considered complementary activities to soy farming and provide additional revenue streams. They can support generating additional income for landowners, thereby reducing the pressure on native vegetation. Agroforestry involves tree or shrub planting around or among other crops and combining agriculture and forestry techniques, which can lead to a rise in productivity and reduced emissions. NTFPs include fruits, nuts, fungi, fibers, charcoal, honey and fish, among others, from existing forestry or agroforestry systems. |

| | |
|---|---|
| **Carbon Markets** | • The growth of global carbon and biodiversity markets has caught the attention of both the Brazilian government and the private sector. These markets can shift perspectives on what has been historically considered 'unproductive land' into valuable assets for their carbon storage and biodiversity as a result of conservation. High-integrity carbon credits, including those at a jurisdictional level, will reduce the risk of price volatility. Investments in nature-based solutions and the bioeconomy present opportunities for diversifying revenue streams for farmers facing growing climate risks. |
| **Double-Cropping** | • An abundance of rainfall and long summer months enable many soy producers to produce two harvests on the same piece of land without the need for additional irrigation and other equipment typically required to extend the growing season.[76] While regionally dependent, an estimated 13 million hectares of soy cropland are harvested and immediately sowed with safrinha corn, a double-cropping practice that has become so successful as to dwarf the standard first-corn harvest. The development of soy varieties adapted to earlier planting has allowed for 40 percent of Brazil's soy area to be followed by a safrinha corn crop, providing producers that engage with the practice an annual source of diversified revenue.[77] However, double-cropping practices depend on strong pest management processes and rainfall, which are increasingly affected by escalating physical climate impacts. |
| **Integrated Crop-Livestock Farming (iCLF)** | • An alternative to double-cropping strategies, iCLF aims to maximize land use efficiency and overall farm productivity through the integration of livestock as opposed to an additional crop harvest.[78] Producers that engage in iCLF may raise their own livestock for slaughter and other livestock products or lease their land in exchange for grazing fees. This practice was shown to increase per hectare profitability by 112 percent when compared to ungrazed land.[79] In addition to revenue diversification, cropland used to support livestock benefits from improved soil quality, enhanced nutrient cycling and better pest control.[80] |

## MARKET DIVERSIFICATION

Soy has a variety of use cases, including biofuels, plant-based proteins, seed oils and feedstock for livestock. Soy supply chains that are nimble enough to adapt to changing demand across market segments can increase resilience to climate transitions. Potential market opportunities include:

| | |
|---|---|
| **Sustainable Aviation Fuels** | • The adoption of sustainable aviation fuels is driving up demand for biofuels, including soy, as airlines work to reduce the emission intensity of travel. |
| **Plant-Based Proteins** | • The plant-based protein market is projected to be worth USD 162 billion by 2030, 4.5 times higher than its 2020 valuation. Plant-based proteins could represent up to 7.7 percent of the global protein market by 2030, which could lead to significant opportunities for soy.[81] |
| **Non-Ruminant Meat Livestock** | • Although feedstock used for ruminant meat production is likely to face reductions in demand as consumer preferences change under climate transitions, feedstock used for other types of livestock will likely increase in demand due to a growing global population. |

# Financial Mechanisms for Investing in Farm Improvements

*While opportunities exist for producers to enhance profitability, existing mechanisms to finance farm improvements are more accessible to market leaders; smallholders face difficulty securing credit due to circumstance, extensive documentation requirements and more.*

## Section 8

Smallholders, those most in need of efficiency improvements in order to remain profitable across transition scenarios, often face the highest barriers to paying significant upfront adoption costs.

Land and nitrogen efficiency improvements, technological innovation, GHG emission reductions and other strategies represent unique approaches to improving the profitability of soy farms while reducing the environmental impact traditionally associated with establishment expansion. However, the costs associated with strategic investments can restrict access to future profitability. Smallholders, those most in need of efficiency improvements in order to remain profitable across transition scenarios, often face the highest barriers to paying significant upfront adoption costs.

Substantial public funding from the Brazilian government has been mobilized in an effort to close the gap. Various programs supporting sustainable practices in agriculture and livestock, including Plano Safra (Harvest

**Market Leader Opportunity. Innovative Financial Instruments to Supplement Soy Farming Income**

The voluntary carbon market has seen rapid growth, reaching USD 2 billion in 2021 up from just USD 200 million five years prior.[86] Brazil, however, is uniquely positioned to succeed in the coming years due to its potential to generate carbon credits. Some estimates suggest that 15 percent of the world's entire carbon offset potential (achievable through natural climate solutions) lies within Brazil.[87] 80 percent, 1.2 – 1.9Gt $CO_2$e, of which is associated with pasture restoration and reforestation projects. Producers that seize the opportunity to certify the restoration of their land have the potential to earn USD 87 per ton of $CO_2$e under the IPR-inspired Forecast Policy scenario by 2050. Similar to carbon markets, the emerging biodiversity credit market is scaling to provide payments for results to protect or restore biodiversity, an important factor in sustaining quality carbon credit efforts to combat emerging threats from biodiversity loss.

With nearly 3.9 million smallholder farms in Brazil, investors who can mitigate the lending issues typically associated with rural applicants could tap into a substantial market in need of credit and financing opportunities.

Plan), ABC+ Plan, RenovAgro and the National Program for Strengthening Family Agriculture (Pronaf), have been developed to provide Rural Credit (CR) to a diverse range of producers, from small to large-scale operations, as well as cooperatives and agribusiness-related companies.

In recent years, the banking sector has increasingly aligned credit lines and financing for the agricultural sector, developing programs targeting socio-environmental practices outside government and regulator initiatives. Programs from BNDES (Proirriga, Prodecoon), Banco do Brasil, Rabobank (Renew Pasture), Santander (CDC Agro Sustainable), Banco do Nordeste (FNE Verde, FNE Sol) and Banco da Amazona (Amazônia Rural Verde, Energia Verde) provide credit for a variety of projects funding land restoration efforts, sustainable farming practices, renewable energy projects and more.

Apart from government and banking financing initiatives, a number of NGOs have found success in driving private sector collaboration through the use of consortiums, with efforts led by the United Nations Environment Programme, the Nature Conservancy and the Tropical Forest Alliance mobilizing USD 10 billion in disbursements for sustainable agriculture. See Appendix 3 for an overview of the existing financial mechanisms for Brazilian soy farmers.

Although extensive financing opportunities have been made available, credit is typically more accessible to market leaders, while smallholders often face approval challenges due to extensive documentation requirements, connectivity issues and other restrictions. 38 percent of a 4,300 strong rural producer union, the Brazilian confederation of agriculture and livestock (CNA), have never received rural-specific credit approval.[82]

Rejection forces producers to seek non-specific bank loans with higher interest rates and less favorable repayment terms than are available through government programs. With nearly 3.9 million smallholder farms in Brazil, investors who can mitigate the lending issues typically associated with rural applicants could tap into a substantial market in need of credit and financing opportunities.[83]

Section 9

# Recommendations for Key Stakeholders

*Collaboration across stakeholder groups and early action can prepare the Brazilian soy sector and the wider economy for climate transitions*


Quantifying and preparing for the risks and opportunities driven by climate transitions is essential to the successful future of the Brazilian soy sector. These transitions present material risks, but they also present significant opportunities. Action today can pay major dividends tomorrow, especially considering that physical impacts are intensifying and closing the window of opportunity.

Interest in investment in sustainable solutions that increase productivity and diversify revenue streams is rapidly increasing. Where risks may limit growth or render some forms of soy production uneconomical, equal or potentially greater opportunities exist to support the economic development of communities now dependent on soy production.

A future that is both sustainable and profitable will require a radical level of collaboration among major stakeholders within Brazil and the support of the international community. There is an opportunity for those who are proactive, and these findings provide an early warning system to prepare for climate transitions. In that spirit, stakeholders can consider enacting the following recommendations in future strategies and efforts.

# Opportunities for Investors

**Assess climate transition risk and vulnerability across investments.**

- Investors who use historical data to calculate risk or who do not include transition risks are likely to underestimate the risk profile of investments.

**Prioritize investments with growth strategies reliant on sustainable agriculture practices, high-efficiency technology solutions, improved management practices and diversified revenue streams over those with growth strategies dependent on geographic expansion.**

- Soy sector expansion through deforestation will likely be unprofitable in the future due to land use restrictions, increased GHG prices and other factors. This is particularly relevant for ecologically important regions, such as the Amazon and the Cerrado.

**Link investments and lending to sustainable practices.**

- Incentivize supplier compliance with the Forest Code through targeted and results-based financing.
- Prioritize market differentiation along international supply chains with deforestation-free regulations and policies through transparency, thereby reducing repayment losses under climate transition pathways.

**Increase investments in innovations that create competitive advantage through the production of deforestation-free products.**

- Collaborate with leading actors to identify promising new technological and management techniques to improve production practices through pilot projects.
- Assess the barriers to adoption for producers that exist today and develop new financial vehicles that will provide the patient capital to support producers through their transition.
- Participate in knowledge-sharing among peers on industry standards for measuring impact, risk monitoring reporting and establishing science-based and nature-positive goals.
- Advocate for expanded catalytic capital that is patient, risk-tolerant, concessionary and flexible enough to accelerate market growth of deforestation-free soy products that have the potential to be most competitive in future export-oriented markets.
- Develop new targets for sustainable agriculture deal origination and update criteria for acceptable risk in financial vehicles.

**Collaborate with producers to provide assistance in navigating transitions.**

- Create financial instruments that are accessible to facilitate uptake among smallholders and family-level operations, prioritizing affordability and low bureaucratic hurdles.

**Identify new opportunities for investment to support new, diversified revenue streams.**

- Continuously evaluate new types of investments that improve the productivity of soy farming and diversify revenue streams for soy farmers.

**Invest in new sectors to support economic growth.**

- Invest in soil health improvements, agroforestry systems, carbon markets and biodiversity markets.

# Opportunities for Soy Producers

**Adopt agricultural management practices and techniques that sustainably increase land productivity and profitability while also reducing production costs. These could include:**

- Employ practices that increase land and nitrogen use efficiency. For example, precision agriculture leverages real-time data and sensor technology to monitor production and equipment while improving the efficiency of seeding, spraying and fertilizer application.
- Invest in agricultural practices that improve soil health and sustainably intensify production on existing land.
- Adopt integrated pest management and cover-crop rotation practices to reduce reliance on pesticides and herbicides.
- Adopt developing farm automation technologies to increase farm efficiency and productivity.
- Maximize GHG emission reductions, especially $CO_2$ and $N_2O$, in order to reduce emissions payments expected under climate transitions.
- Opt to move toward land ownership, where feasible, to mitigate the risk of rising land prices under climate transitions.
- Invest in storage to improve resilience to economic shocks that cause short-term volatility in commodity prices and transportation costs.

**Identify and advocate for financing opportunities that allow farmers to better prepare for climate transitions.**

- Acquire loans from financial institutions, development banks and government to support upfront investment costs in technological and productivity improvements.
- Provide support for profitably incorporating nature-based solutions across soy production landscapes.

# Opportunities for Traders and Processors

**Adopt comprehensive monitoring practices to ensure the traceability of all inputs involved in the supply chain.**

- Conduct effective monitoring, which plays a pivotal role in eradicating deforestation-linked soy from the entire supply chain, ultimately enhancing the reputation and market access of products in both domestic and international markets.

**Promote and implement programs to achieve zero deforestation throughout the entire supply chain and provide financing for technological investments that sustainably increase yield for suppliers.[88]**

- Work with other stakeholders to test financial products that increase supply chain transparency. Feature clear deforestation and conversion-free labeling on product packaging to allow sustainable producers to maintain market access and potentially benefit from differentiated pricing and resources.
- Finance technical assistance for producers to expand adoption of solutions that sustainably improve productivity while achieving deforestation-free agriculture.

**Conduct comprehensive climate transition risk assessments to ensure the sustainability of the soy supply under climate transitions.**

- Utilize scenario analysis to better understand and prepare for climate transitions and to help suppliers mitigate risks.

# Opportunities for Brazillian Policymakers

**Improve clarity through consistent and reliable policymaking.**

- Follow through on the full implementation of landmark policies such as the Forest Code and the revised PPCDAm to give stakeholders certainty around policy impacts while mitigating physical climate risks that could threaten the entire Brazilian soy industry if access to rainfall for irrigation is reduced, temperatures threaten yields and extreme weather events drive uncertainty.
- Provide clarity on land use rights and tenure, especially for smallholder and family-level operations.

**Support data collection and monitoring to serve more efficient land use strategies.**

- Employ advanced monitoring systems and high-quality data for land management improvement, increasing land use efficiency and high carbon stock land conservation.

**Provide support for soy farmers during climate transitions.**

- Foster a financial regulatory environment that enables farms to fund efforts to transition to more resilient systems.
- Link a greater share of Brazilian agricultural subsidies with sustainable land use practices to encourage soy farmers to adopt high-efficiency technology, sustainable farming strategies and improved management practices.
- Expand extension services and access to technical assistance to increase the capacity of farmers of all types to adopt technically complex and innovative practices.
- Consider long-term metrics for measuring progress to unlock patient capital. Although these policies require large initial investments, they increase yield and profitability in the long term and will help the Brazilian soy sector maintain competitiveness in international trade.
- Support the scaling of nature-based solutions in soy production landscapes as both a climate adaptation measure (climate attenuation effect of forests) and a financial derisking element through diversification.

# Opportunities for International Policymakers

**Develop future climate, biodiversity and sustainability policies collaboratively with Brazilian stakeholders.**

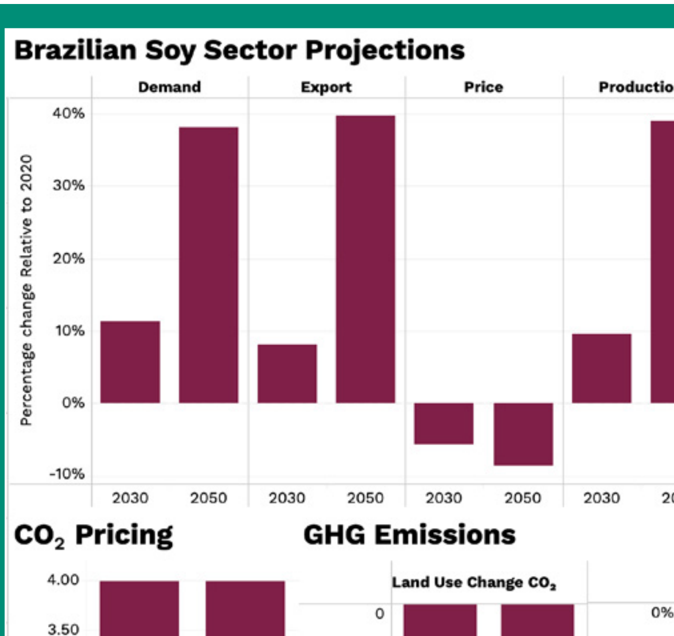
- Create new international trade arrangements that will enable Brazil's agricultural sector to meet the growing global demand for food while increasing the resilience of the food supply through transitioning to sustainable production.
- Work through established initiatives, such as the Amazon Fund, to support Brazil's sustainable economic development.[89] This proven funding mechanism can incentivize the reduction of deforestation through programs that support improved soy production practices and strengthen rural community economies.
- Support the development of nature-positive soy production landscape initiatives based on existing policies and financial mechanisms.

# Orbitas Brazil Project: Digital Risk Assessment Tools

These tools delve into the material risks and opportunities that cattle and soy farmers may encounter under climate transitions through 2050. This equips users with the essential information to navigate climate-related challenges, offering insights into investment opportunities and enabling informed decision-making within the agricultural sector.

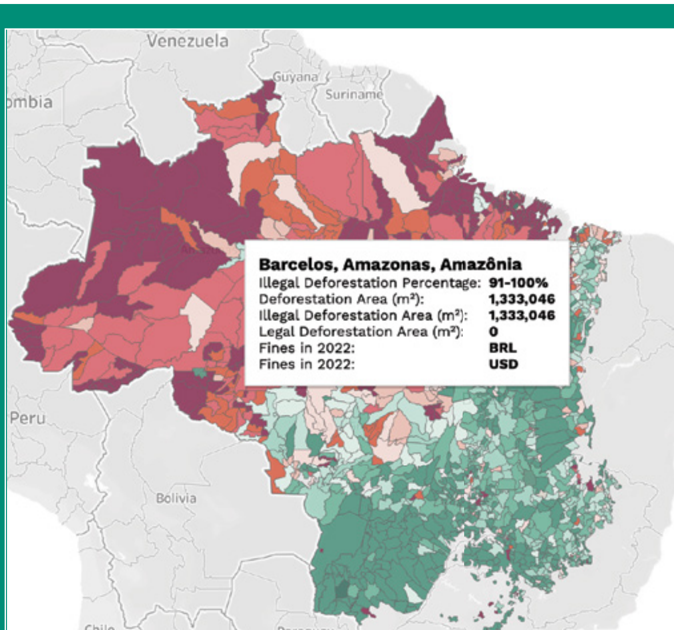
**USE THE TOOLS**

**Available at:**
orbitas.finance/brazil-agriculture-tools




## Soy Sector Analyzer

Understand the material risks and opportunities associated with climate transitions and the financial risks associated with potential shocks for yield, transportation costs and product prices that soy farmers are likely to encounter between now and 2050.




## Illegal Deforestation Risk Analyzer

Examine the distribution of illegal deforestation risk and enforcement fines across Amazônia, Cerrado and Pantanal biomes in Brazil.

ORBITAS
A Climate Advisers Initiative

# Brazil's Soy Sector Amidst Climate Transitions

## Appendices



Orbitas
April 2024

# Appendix 1: Evolution of Materialized Physical Risks by Biome

*Results from weather station data across the Cerrado and particularly the MATOPIBA*

FIGURE A1.

**COMPARISON OF CLIMATE AVERAGES BETWEEN 1991–2020 AND 1961–1990 IN CERRADO AND MATOPIBA**

| | SUMMER | | | AUTUMN | | | WINTER | | | SPRING | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1961–1990 | 1991–2020 | Dif. | 1961–1990 | 1991–2020 | Dif. | 1961–1990 | 1991–2020 | Dif. | 1961–1990 | 1991–2020 | Dif. |
| **Cerrado** | | | | | | | | | | | | |
| TMax (°C) | 30.0 | 31.0 | 1.0 | 29.9 | 30.6 | 0.7 | 29.7 | 30.6 | 0.9 | 31.3 | 32.7 | 1.4 |
| TMean (°C) | 24.0 | 24.9 | 0.9 | 23.3 | 24.0 | 0.7 | 21.6 | 22.6 | 1.0 | 24.4 | 25.6 | 1.2 |
| TMin ( °C) | 20.0 | 20.8 | 0.7 | 18.8 | 19.5 | 0.7 | 15.5 | 16.4 | 1.0 | 19.3 | 20.3 | 1.0 |
| Rainfall (mm) | 662.5 | 657.4 | -5.1 | 356.2 | 365.8 | 9.6 | 38.0 | 26.9 | -11.2 | 322.9 | 303.1 | -19.9 |
| Evaporation (mm) | 271.8 | 307.8 | 35.9 | 250.8 | 284.4 | 33.7 | 336.4 | 391.3 | 55.0 | 366.9 | 437.4 | 70.4 |
| Relative Humidity (Percent) | 78.8 | 75.8 | -3.0 | 75.8 | 73.0 | -2.8 | 62.5 | 58.1 | -4.4 | 66.6 | 60.5 | -6.0 |
| **MATOPIBA** | | | | | | | | | | | | |
| TMax (°C) | 31.2 | 32.3 | 1.2 | 31.3 | 32.3 | 0.9 | 32.8 | 33.8 | 1.0 | 33.6 | 35.2 | 1.6 |
| TMean (°C) | 25.2 | 26.5 | 1.3 | 25.3 | 26.4 | 1.2 | 24.9 | 26.3 | 1.4 | 26.7 | 28.3 | 1.6 |
| TMin ( °C) | 21.3 | 22.2 | 0.9 | 21.0 | 21.8 | 0.8 | 18.6 | 19.7 | 1.1 | 21.3 | 22.4 | 1.0 |
| Rainfall (mm) | 609.2 | 584.8 | -24.4 | 492.6 | 472.4 | -20.2 | 36.1 | 24.4 | -11.7 | 247.2 | 220.7 | -26.5 |
| Evaporation (mm) | 242.4 | 285.8 | 43.5 | 265.0 | 313.9 | 48.9 | 586.9 | 655.2 | 68.3 | 485.3 | 586.1 | 100.8 |
| Relative Humidity (Percent) | 79.6 | 76.9 | -2.6 | 78.5 | 75.2 | -3.4 | 61.0 | 56.9 | -4.1 | 64.2 | 58.3 | -5.9 |

Source: Authors' modeling. Data: Brazilian National Meteorological Institute (INMET – Instituto Brasileiro de Meteorologia)

# Appendix 2: Detailed Modeling Assumptions

*The scale and pace of climate transitions are still unknown, but scenarios can project how the Brazilian soy industry would perform across various climate transition pathways*

FIGURE A2.

| | BASELINE | MODEST ACTION | | AGGRESSIVE ACTION | |
|---|---|---|---|---|---|
| **Scenarios** | Business as Usual Scenario (BAU) | Forecast Policy Scenario by Inevitable Policy Response | Coordinated Policy Scenario | Societal Transformation Scenario | Innovation Scenario |
| **Warming Target** (Degrees Celsius) | > 3 | < 2 | < 2 | < 1.5 | < 1.5 |
| **GHG Prices by 2050*** (2005 USD per ton of $CO_2$ emissions) | USD 4 | USD 87 | USD 100 | USD 153 | USD 153 |
| **Bioenergy Demand** (EJ/year in 2050) | < 10<br>1st generation biomass | 90<br>2nd generation | 90<br>2nd generation | 100<br>2nd generation | 130<br>2nd generation |
| **Diet Shifts** (Demand for livestock products between 2020 and 2050, kcal/cap/day) | No shift | < 600 | < 600 | < 450 | < 600 |
| **Protected Areas**** | WDPA† (~15% globally) by 2050 | WDPA (~15% globally) + Biodiversity hotspots by 2035 | WDPA (~15% globally) + Biodiversity hotspots by 2030 | Expand current WDPA (~15%) toward 30% by 2030 | WDPA (~15% globally) + Biodiversity hotspots by 2030 |
| **Input Efficiency** (Nitrogen Uptake Efficiency by 2050) | 60% | 65% | 65% | 65% | 75% |
| **Yield-Enhancing Tech** | Low change | Medium change | Medium change | Medium change | High change |
| **Food Waste Reductions** (Percent of food wasted by 2050) | 33% | 20% | 20% | 16.5% | 20% |
| **Other Climate Policies** | Existing national policies on reforestation and reduced deforestation. Does not include ambitious pledges in support of the Paris Agreement | Include Ambitious pledges for reforestation and reduced deforestation in support of the Paris Agreement | | | |
| **Timber Demand** | Low level | Moderate level | Moderate level | Moderate level | High level |

Source: Orbitas is collaborating with World Business Council for Sustainable Development (WBCSD) and Vivid Economics to drive greater alignment around climate transition scenarios assumptions. The scenarios are based on the WBCSD transition scenario tool, which was inspired by Orbitas phase 1 scenarios, with modifications to incorporate recent developments. See here for the earlier WBCSD tool: https://www.wbcsd.org/Programs/Redefining-Value/ TCFD/News/WBCSD-releases-new-climate-transition-scenario-tool-for-companies-in-the-Food-Agriculture-and-Forest-Products-sectors

*GHG prices presented are averaged global values in 2005 USD. They reflect the assumed prices of GHG emissions from agriculture, forestry and other land use;

**"Protected areas," based on the World Database for Protected Areas, include all areas under legal protection meeting the International Union for Conservation of Nature (IUCN) and Convention on Biological Diversity protected area definitions (including IUCN categories Ia, Ib, III, IV, V, VI);

†World Database for Protected Areas.

# Appendix 3: Existing Mechanisms for Financing Investments in Climate Resilience

*Numerous opportunities exist for market leaders to enhance profitability through diversification of revenue streams and for the broader Brazilian soy sector to invest in innovation.*

Significant progress is needed to ensure that access to resources to mitigate climate transition risks and lean into opportunities is equitable and accessible

The collaborative efforts of the following initiatives are improving the environment for investors to understand the risks and potential opportunities for financing soy production, which is rapidly diverging from traditional practices. However, significant progress is needed to ensure that access to resources to mitigate climate transition risks and lean into opportunities is equitable and accessible.

## Brazilian Government Financing Initiatives

- Plano Safra is the primary governmental policy aimed at encouraging agricultural activity. In the past year, it provided a record USD 72.8 billion in credit while introducing mechanisms to promote socio-environmental attributes and preventing credit issuance to individuals engaged in illegal activities. The project allocated USD 1.4 billion for credit lines aimed at stimulating low-carbon agricultural activities. Moreover, the government unveiled the Plano Safra for Family Farming 2023/2024, with a budget of USD 14.32 billion.
- The ABC+ Plan 2020–2030 represents the second phase of the Sectoral Plan for Mitigation and Adaptation to Climate Change for the Consolidation of a Low Carbon Economy in Agriculture. Its objective is to reduce carbon emissions by 1.1 billion tons in agribusiness by promoting the adoption of sustainable technologies, such as recovery of degraded pastures, the No-Tillage System (SPD), and the integration of agriculture, livestock and forestry (ILPF). The plan also provides a financing line focused on the adoption of sustainable technologies, now known as the Program for Financing Sustainable Agricultural Production Systems (RenovAgro).
- Finally, institutions such as Banco da Amazônia manage financial resources from government programs aimed at the development of states in the northern region, which includes supporting rural producers and promoting sustainable practices in the field.

## Private Sector Financing Initiatives

- BNDES offers a range of financing options for the agribusiness sector aimed at reducing environmental impacts, including equipment purchases. BNDES Proirriga supports the development of sustainable irrigated agriculture, while Prodecoop focuses on modernizing productive systems and marketing for cooperatives, among others. The Climate Fund, a specific federal government program for climate change, supports projects related to climate mitigation and adaptation, with an allocation of USD 0.6 billion for 2023. The priority is to invest in renewable energy projects and energy efficiency.
- Banco do Brasil offers rural credit solutions following an analysis of financial, climate and market risks. The goal is to incentivize producers to implement business management improvements and adopt socio-environmental practices. Some programs include Low Carbon Agriculture, Innovation and Best Practices and BB Reforesting Brazil, in addition to other options focused on sustainable agribusiness practices, such as integrated agriculture-livestock-forestry, recovery of degraded pastures and compliance with Legal Reserve and Permanent Preservation Areas.
- Rabobank positions itself as a specialized bank that provides financial and strategic solutions for agribusiness. It offers financing focused on sustainability and has recently collaborated with the United Nations Environment Program and other international partners to develop "Renew

Pasture," a loan with a three-year grace period aimed at enabling clients to recover low productivity and degraded pastures.

- Santander facilitates the transfer of credit lines from government programs and also offers its own program, CDC Agro Sustainable. This program supports the purchase of machinery and low environmental impact planting and livestock technical solutions, the implementation of renewable energy systems, drip irrigation and other sustainable practices.
- Banco do Nordeste offers FNE Verde (Green FNE), aimed at financing projects and activities that seek environmental conservation and recovery for rural producers and cooperatives. FNE Sol (FNE Sun) finances micro- and mini-generation projects of energy from renewable sources for self-consumption or leasing.
- Banco da Amazônia offers Amazônia Rural Verde (Green Rural Amazon), targeting rural producers and traditional populations in the region to finance sustainable activities. This includes the transformation of timber forest products from managed areas, reforestation and land recovery. Energia Verde (Green Energy) is another credit line focused on the purchase of vehicles that use renewable energy.

## Consortium and NGO-Driven Financing Initiatives

- The Innovative Finance for the Amazon, Cerrado and Chaco initiative led by the United Nations Environment Programme, the Nature Conservancy and the Tropical Forest Alliance has committed to mobilizing USD 10 billion in commitments and disbursements of funds for the sustainable agricultural transition by 2030. The initiative sees the development of deforestation-free cattle, soy, agroforestry and non-timber forest products across critical South American biomes, including the Brazilian Amazon and Cerrado, as a USD 30 billion opportunity for investors.
- The Investors Policy Dialogue on Deforestation (IPDD) is a consortium of financiers with USD 8.5 trillion in assets under management led by a secretariat established by the World Economic Forum and supported by the Principles for Responsible Investment. IPDD, established in 2020, is composed of 58 financial institutions and investors concerned about the "financial impacts that deforestation and the violation of the rights of indigenous peoples and local communities may have on their clients and investee companies by potentially increasing reputational, operational and regulatory risks." It identifies three channels by which deforestation risks create financial risk for issuers and investors: ESG risks, supply chain risks and finance sector risks.
- Capital for Climate provides a platform for large-scale investors to focus primary capital on sustainable livestock management, restoration of degraded pastureland, regenerative agriculture, agroforestry, the bioeconomy and other relatively new bankable assets.

## Innovative Financial Instruments: Nature-Based Solutions and Bioeconomy Financing Initiatives

The voluntary carbon market has seen rapid growth in recent years, especially among nature-based solution projects and programs. Brazilian policymakers, private sector leaders and Indigenous communities are proactively seeking opportunities to work with financiers and carbon market stakeholders to grow the nation's market. For example, the LEAF Coalition is working with the Amazonian Brazilian states of Amapá, Amazonas, Acre, Mato Grosso and Para to generate jurisdictional carbon credits that will be sold on the voluntary carbon market. Carbon markets are set to expand as Article 6 negotiations are finalized, allowing the Brazilian national government to seek more investment from other nations to purchase carbon credits generated by conserving and restoring the nation's natural habitats.

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