UNIVERSITY OF CAMBRIDGE
INSTITUTE FOR SUSTAINABILITY LEADERSHIP

Case Study

Nature-related financial risk: use case

How soil degradation amplifies the financial vulnerability of listed companies in the agricultural value chain

NATURE POSITIVE

ROBECO
The Investment Engineers

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The Investment Leaders Group (ILG) is a global network of pension funds, insurers and asset managers, with over US $12 trillion under management and advice. The ILG's vision is an investment chain in which economic, social and environmental sustainability are delivered as an outcome of the investment process as investors go about generating robust, long-term returns. It is convened by CISL.

Preface

Members of the Investment Leaders Group and Banking Environment Initiative are working with the Cambridge Institute for Sustainability Leadership (CISL) and academic partners from the University of Cambridge to determine a common language and framework for financial institutions to identify and assess nature-related financial risks, so that these risks can be measured and managed.

The collaboration has so far detailed the financial materiality of biodiversity loss and land degradation and published its cornerstone Handbook for Nature-related Financial Risks in March 2021. The Handbook explains how specific sources and types of nature loss, and the response to that loss, result in financial risk, explaining key concepts and providing a method for risk identification and assessment. During the following phase of work, financial institutions within the project used this Handbook to develop use cases that demonstrate how nature-related risks manifest in their portfolios.

This paper is one of a series of use cases, each assessing a specific type of nature-related financial risk. Financial institutions led the risk assessment process and subsequent write-ups in close collaboration with the CISL team, who offered guidance, input and support.

The purpose of these use cases is to enable and galvanise further assessments of nature-related risk across the financial system. Detailing the risk assessment process aims to show ways in which the wider financial industry can make such assessments of its own. All financial firms are vulnerable to nature-related financial risks, and the financial materiality of nature loss evidenced constitutes an urgent call to action.

The more that assessments are undertaken and shared, the easier it will be for others to follow and understand the urgency of managing nature-related risks. Through the creation of these use cases, financial institutions have started to generate internal engagement regarding nature loss, as well as catalysing new conversations with clients and investee companies. Through these conversations, collaborative strategies can emerge to mitigate nature loss and support a transition to a nature-positive economy.

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Executive Summary

In this paper we assess **how exposure to degraded land can impact the value of listed companies** in the food supply chain.[1]

To answer this question, the research focuses on the amplifying effect that exposure to degraded land can have following an extreme weather event, such as drought, and how this impacts parts of the agricultural value chain. The findings show that healthy soil is a differentiating factor between negative and positive market value.

The research took a national approach by focusing on Brazil, a country that, over past decades, has played a key role in the expansion of agricultural crop markets globally. Given the growing dependency of the global population on Brazil's agricultural output, it is particularly important to gain an understanding of the vulnerability of its agricultural supply chain.

In order to examine how soil degradation increases the financial vulnerability of listed companies, a stress test was conducted. This stress test applied a scenario about extreme weather and the vulnerability to degraded land of several companies in the pre-production, production, distribution and consumption parts of the value chain. For each part of the value chain, these companies were categorised as having local or globally diversified operations, enabling conclusions to be drawn about which part of the chain would be impacted and how this would affect both large, diversified companies and small, local operators.

Analysis relied upon previous land degradation research and, in particular, the study published by PBL Netherlands, the Dutch Environmental Assessment Agency, which estimated that approximately 4 per cent of land in South America is degrading. This figure is fairly low compared to other parts of the world, and it might be higher in certain regions of Brazil due to increased deforestation and land exploitation.[2] For example, the Cerrado biome, in the mid-west of the country, is experiencing various forms of land degradation, becoming more vulnerable to fires in an environment that is also becoming hotter.[3,4,5] These factors are not considered in our scenario, but such developments would likely reinforce the conclusions drawn by the research that soil degradation in Brazil is a financially material risk.

Exposure to degraded land causes financial vulnerability throughout the value chain

The stress test scenario saw the market value of farmers operating largely on degrading land decline by 13 per cent following extreme weather, while those on healthy soils saw a valuation uplift of 6 per cent (mainly due to their ability to capture crop price rises). These findings have implications further down the chain, as fertiliser trading companies linked to farmers operating on degrading land will likely need to extend payment terms and could face financial losses.

Small-scale (local) companies with exposure to degrading land are most vulnerable, while large corporates profit during 'supply shock'

There are large differences between the impact of the stress scenario on companies that operate globally and local producers whose business models are linked to a specific region. Larger listed fertiliser and trading companies that have limited exposure to degraded land could even benefit from an extreme weather event and see their market value increase as a result of additional revenues generated by the inflationary effect. In contrast, small packaged food companies connected to degrading land suffer a negative impact on valuation of as high as 45 per cent. Increased purchasing costs, caused by the need to cover supply shortfalls using increasingly expensive spot markets, cannot be passed on to consumers without risking loss of market share to rivals not connected to degrading land.

Companies with large exposure to degraded land are at risk from economic tipping points

The report has not modelled intermediate changes in capital costs or working capital swings for the farmers and has assumed volumes would return to normal for local producers operating on degrading land after a period of three years. However, farmers may reach an economic tipping point where they struggle to cover capital costs before the end of this three-year period. Industry interviews confirmed that such tipping points have occurred in the past, with large farming companies divesting land in the Bahia and Piaui regions because harvests were becoming too unpredictable.

Call for action

There is a significant risk of asset value deterioration for companies in the chain exposed to land degradation. As such, investors must incorporate land degradation, as a long-term material risk, within their investment decision-making processes and actively engage with companies in the agribusiness sector to mitigate them.

Within the agricultural value chain, companies linked to degrading land are more at risk of negative financial impacts following extreme weather events. However, there are risks to the entire value chain, including fluctuating balance sheets, a decline in global crop volumes, working capital implications and increased inflation levels impacting food producer profits and increasing consumer costs. Educating and incentivising farmers to invest in soil health is in the interest of all value chain actors.

The findings of this report also underscore how, to avert land degradation risk, assure food security and support the future competitiveness of local companies, governments need to develop policies that promote and support sustainable land use practices.

Introduction

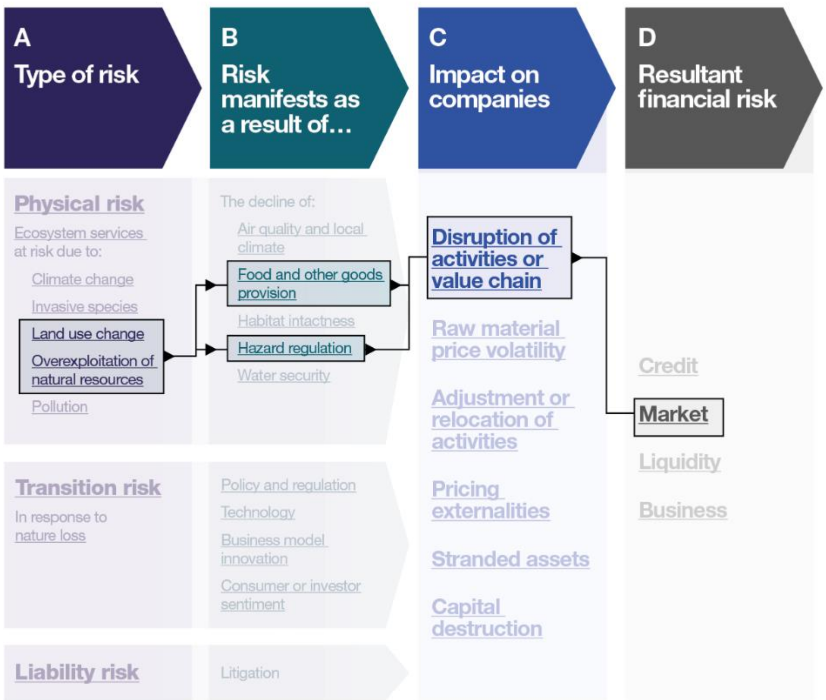
This research focuses on how soil degradation affects the financial vulnerability of companies along the agricultural value chain by comparing the impacts of extreme weather events on the value of companies operating on, or connected to, degrading soil and those who are not. As such, its focus extends beyond the confines of a farm. Furthermore, developments within the agri-food industry point to an intensification of global trade through broad value chain integration; hence, a farm-based stress event will increasingly impact the whole chain.[6]

The first step in the assessment of how soil degradation affects financial vulnerability along the agricultural value chain was the application of a stress test scenario in which an extreme weather event impacted crop production in a specific location (Brazil).[7]

The premise for this research is that, from an investment perspective, assessing the financial risk related to land degradation exposure as a material sustainability risk factor needs to be integrated in the investment analysis process. This is because it is part of the fiduciary duty of asset managers to integrate sustainability risks in the investment process, addressing and managing those risks, in order to protect the client asset value.

Using CISL's Handbook for Nature-related Risks (Figure 1), the research focused on the market risk (column D, 'resultant financial risk') posed by disruption (column C, 'impact on companies') that is a result of the degradation of land (column B, how the 'risk manifests') caused by land use change and overexploitation (column A, 'type of risk').[8]

Figure 1: Framework for identifying nature-related financial risks



Source: University of Cambridge Institute for Sustainability Leadership Handbook for Nature-related Financial Risks

The climate-vulnerable region examined for this report was the Brazilian 'grain belt', the Cerrado biome (Appendix I, Figure 7), given its relevance to global crop production and the key role it plays in land expansion for cultivation.[9]

The report forecasts the variations in value of four archetype companies related to pre-production (fertiliser producer), production (farming company), distribution (trading company) and packaged food (food producer). For each, the research used one or, in some cases, two proxy companies and a ten-year discount cash flow model to calculate their fair value.

A review of existing literature on land degradation, expectations of crop and food production growth, financial statements of companies in the four segments of the chain, and market research referring to price impact of climate events was undertaken. In addition, interviews were conducted with sector specialists and global and local companies with assets and operations in the region to better assess how they viewed climate and nature as inherent business risks.

In summary, the research explored:

1) the impact of an extreme weather event from an operational and stock value perspective on those connected to (and not connected to) degrading land – the stress scenario.
2) which types of companies in the value chain were most exposed to the stress scenario.
3) the extent to which exposure to degraded land increased financial risk.

What is soil degradation and why does it matter?

According to England's Environment Agency, soil health can be defined as "the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals and humans." Amongst the essential services that healthy soil provides are water absorption, reducing risk of flooding, water filtration, climate regulation and gas absorption in the atmosphere (soil holds three times as much carbon as the air), as well as the provision of habitat for soil-dwelling organisms and, most relevant for this paper, a conducive environment for food to grow.

Healthy soil is crucial to sustain long-term crop yields, food quality and extreme weather resilience. Previous research has found that the impacts of extreme weather on degraded land can be twice as severe as in areas with healthy soil and that this can lead to permanent reductions in yield.[10]

Evidence of global soil degradation is common. In its landmark publication 'Exploring future changes in land use and land condition and the impacts on food, water, climate change and biodiversity', PBL stated that about 12 per cent of global agricultural land shows a downward productivity trend.[i] The actual number might be more severe as the study did not take the future effects of climate change into account. In addition, the severity of the impacts may differ from region to region. For instance, 17 per cent of soil in England shows signs of erosion, but nearly 40 per cent of soil is thought to be at risk.[11]

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[i] Note that this number is not corrected for any decline in productivity that may be artificially maintained by anthropogenic fertiliser application.

Several factors compromise the health of soil. Land where heavy machinery is used to grow root crops, maize or winter cereals is often degraded as a result of compaction. Another important factor is erosion. Soil usage can be called sustainable as long as erosion does not exceed the rate of formation. However, the rate of formation is rather slow, and agricultural intensification has led to an increase in erosion. As fields increase in size, the length of hedgerows decreases, leaving the soil more susceptible to wind and water erosion. Poor farming practices can increase erosion risk significantly, whilst integrating trees into arable crop areas has been found to potentially reduce erosion by nearly two thirds.[12] Land use change, as well as reduced levels of organic matter due to ploughing, monoculture practices, intensive use of chemicals and bad nutrient management (overuse of nitrogen), also contribute to the erosion. Furthermore, unsustainable farming practices decrease not only the fertility of soil, but also its resilience.

Soil degradation in the Brazilian context

Brazil is one of the biggest global agricultural commodity producers (Appendix I, Figures 1 and 2). Its production in the past years has grown rapidly due to the increasingly widespread application of yield-enhancing measures from intensive farming practices, in combination with favourable soil and climate conditions.

Whilst the increase in crop output has been of significant importance to the country's trade balance and the global food industry, the growth in production has resulted in degradation in most local producing areas.[13, 14]

Almost half of the Cerrado, a region of native savanna vegetation, has been cleared for crops and cattle. Without wild plants to absorb sunlight, heat is absorbed by the land or flows into the atmosphere. During certain times of the year, cropland is left totally bare, exacerbating the problem.[15]

Figure 2: Cleared land in Brazil's Matopiba region

Source: https://climainfo.org.br/2021/07/30/degradacao-ambiental-colapso-do-cerrado-pode-acontecer-nos-proximos-30-anos-diz-estudo/

Courtesy of Luiz Flamarion Barbosa de Oliveira

Soil degradation is an issue in many regions experiencing an advanced process of desertification.[16] Its advance in regions is associated with deforestation, such as the Cerrado and Amazon biomes (Appendix I, Figures 3–6), which has reduced air moisture and water flows. The replacement of native vegetation with crops also reduces sunlight absorption levels, leading to increased temperatures.[17]

The loss of native forest and biodiversity in several regions of Brazil poses a further challenge to the health of soil; specifically, land degradation and deforestation may mean the Cerrado reaches a local climate tipping point, past which local climate conditions could not sustain current food production. This eventuality poses a significant future risk to the global agribusiness and food industries, as well as global food security – a risk that can be aggravated by both policy inaction and climate change.

Within this context, it is increasingly relevant to analyse how the exposure of companies in the food supply chain to degrading land will impact their financial health following an extreme weather event.

Stress Scenario Applied

In order to investigate the economic impact of exposure to land degradation along the agricultural value chain, scenario analysis compared the impacts of an extreme weather event on companies with, and without, exposure to degrading land. Throughout the research, we were specifically interested in the potential amplifying effect that soil degradation had during the dry season and the financial consequences, building on research assessing the effects of the 1930s American Dust Bowl and other academic studies.[ii] Utilising this academic research, our scenario analysis assumed there were severe and longer-lasting yield reductions from areas with degrading land following an extreme weather event.[18] Our focus on a drought event is just one approach – degrading land is vulnerable to many forms of extreme weather with extreme rainfall and/or storms thought to be more impactful in areas where land is already degrading.

Our research focused on the Brazilian agricultural chain. Previous research by PBL found that four per cent of arable farmers across South America are located on land that is degrading and hence run additional economic risks.[19] This four per cent of arable land degrading is 'climate-corrected', meaning that it removes the impact of climate change to reflect the amount of land degrading due to the way it is managed.

In our scenario, we assumed that severe drought gave rise to immediate yield loss. Studies have shown that the average impact of a severe drought on yields over recent decades is around 20 per cent.[20] The effects could, however, be twice as severe in areas with severe degradation. In addition, loss in yields could be permanent if no action is taken. By contrast, the impact would most likely be less than 20 per cent in regions of high soil quality, highlighting the difference between farms with degraded soil and those operating on healthy land.

In order to simplify our assessment and highlight the potential risks, we assumed that farms located on degraded soil lost 40 per cent of their yields. This figure was at the upper end of the scale indicated by the research used in this study, with yield restoration taking three years.

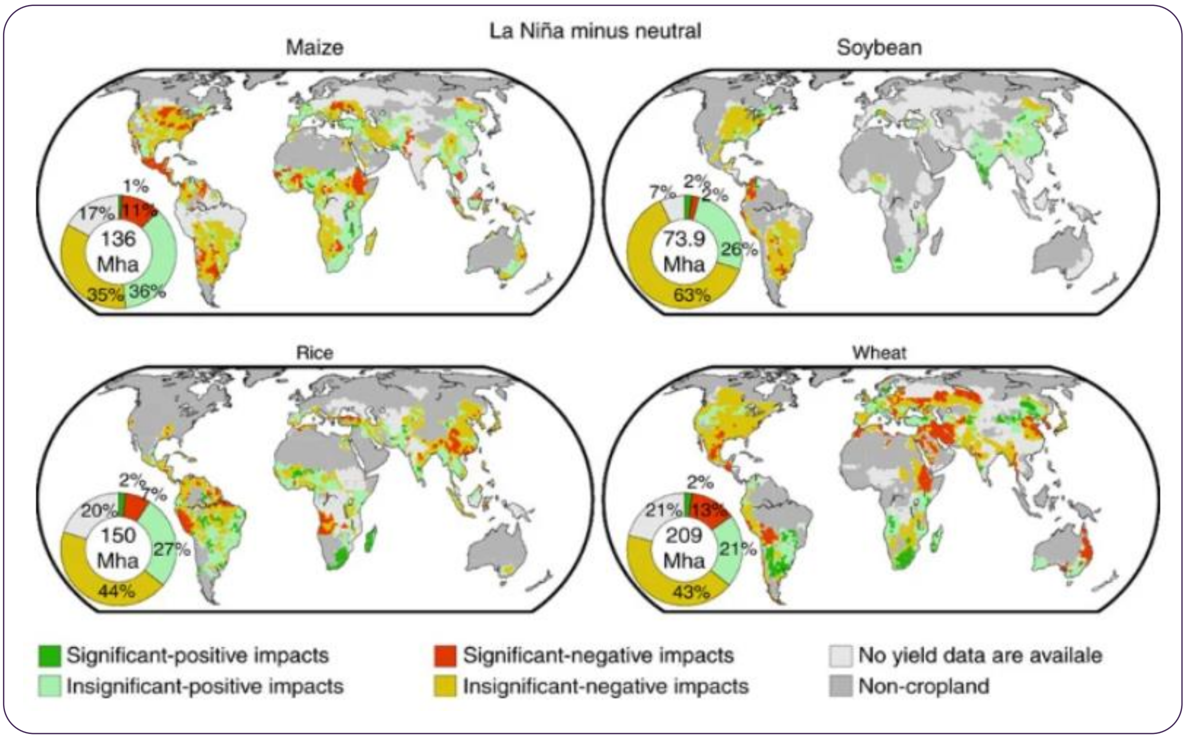
We assumed that farmers on unproductive land were able to reduce variable costs to zero, as it was unlikely that planting would resume on a degraded area. Farmers located on healthy soils saw their yields drop by 10 per cent in year one, but volumes were restored in the second year.

We undertook observations during La Niña periods to gather data points that provided the average negative impact on South American crop yields following an extreme weather event.[21]

Loss of yields is not the only effect of a drought event. In major agricultural production areas, such as Latin America, such an event also results in supply shortages, causing soft commodity prices to spike. Forecasting soft commodity prices is beyond the scope of this paper. A simple approach was instead used, observing the average price increase in years registering a strong La Niña phenomenon in recent decades.

[ii] The Dust Bowl was a period of severe dust storms that resulted in significant land erosion, particularly in areas where there were already levels of degradation. One study of this period concluded there was a widespread, severe and long-lasting impact on agricultural production following an extremely dry season.

Figure 3: Impacts of La Niña on crop yield anomalies



Source: Impacts of El Niño Southern Oscillation on the global yields of major crops[21]

In order to establish price impacts for our models, we observed the variation in price of soy, corn, wheat and cotton at different periods during severe La Niña events.[22] Average falls in soft commodity prices following La Niña were more than 40 per cent for around 18 months. We conservatively calculated that this led to a 40 per cent uplift in soft commodity prices by year two of our stress scenario. It is simplistically assumed that such price increases were equal across all crop varieties.

Increases in fertiliser prices are another likely result of imbalances in soft commodity markets. High crop prices typically lead to expansion of acreage and increased demand for fertilisers. Using a historic averages approach and rounding the effect, there was, again, a price increase of 40 per cent by the second year. Although the effect would, in reality, likely be different for different types of fertilisers, we again simplistically assume the price increase to be equal for all fertiliser types.

Table 1: Overview of main scenario assumptions

Assumptions	Validation
Yields in geography decline by 20 per cent in year 1	Hornbeck, 2012; Bras, Jagermeyr & Siexas, 2019; Liu/Basso, 2020
Yields in degraded area decline by 40 per cent in years 1–3	Hornbeck, 2012; Bras, Jagermeyr & Siexas, 2019; Liu/Basso, 2020
Variable costs on degraded land decline to zero during years of no production (except year 1)	Consultation with expert
Soft commodity prices increase by 40 per cent in year 2	Historic average after strong La Niña years register, US National Weather Service
Fertiliser prices increase by 40 per cent in year 2	Historic average after strong La Niña years register, US National Weather Service

Impact of stress scenario on companies along the agricultural value chain

Companies along the value chain were selected as case studies to understand the financial materiality of direct, or indirect, exposure to land degradation in the face of an extreme weather event.

The first supply chain phase is ‘pre-production’, which involves the production of agricultural inputs such as crop protection chemicals, fertiliser and seeds. Although the research focused on fertiliser companies, we think the effects described will be more or less similar for crop protection chemical and seed producers.

In the ‘production’ stage, farmers deal with everything involved with growing and harvesting. The difference between farmers operating on degraded soil and those located in areas with healthy and well-maintained soil was a key part of our analysis.

The next stage involves everything needed to deliver food from the farmer to the consumer’s plate, encompassing processors, packagers and companies engaged with transportation, retail and trading. To cover this part of the chain, we analysed trading companies and food processors. The ‘consumer’ stage, involving cooking, eating and waste management, was out of scope of the research.

Figure 4: Overview of agricultural value chain

Source: CIAT (https://cgspace.cgiar.org)

Company A – Pre-production

For the purpose of this research, our focus is fertiliser producers, although most of the trends we describe can be extrapolated to the other subsegments of the pre-production part of the chain. We have used a proxy company to showcase the potential effects of extreme weather on this part of the value chain and the extent to which this differs between companies with, and without, exposure to degrading land.

The stress test model assumed the following:

- Working capital: cost of inventory likely higher, although this is uncertain and not likely to be material. Hence, we assume a neutral effect.
- Pricing: we assume a 40 per cent positive price increase in year two following the extreme weather event (drought), based on historical fertiliser price movements post-La Niña.
- Volume: minimal impact.
- Credit loss: minimal impact.

Post-drought, multiple effects would impact fertiliser manufacturers. Extreme weather events would impact small companies to a greater degree than larger ones, specifically those engaged with farms operating on degrading land, where yield reduction would be more pronounced. With regard to credit exposure, fertiliser businesses may be impacted by farming companies who, in the event of a drought, might run into payment problems. This could lead to extension of payment terms and subsequent working capital outflows or even permanent credit losses.

At least 4 per cent of agricultural land in Brazil is degrading. However, the most severe effects of a drought event will most likely be concentrated within these specific geographic areas. Reliance on economic activity in such areas would make fertiliser companies vulnerable.

The fertiliser industry is highly consolidated, with the largest six potash producers being responsible for 70 per cent of global output. The logistical network, scale and sourcing advantages of these companies puts them on a low position on global cost curves, which would give them the opportunity to redirect their sales towards other regions if demand falls away in dry seasons. In addition, these companies typically have insurance policies that provide some protection against income loss from extreme weather events.

It seems likely that industry leaders are mostly insulated from the financial damage that occurs within farming companies operating on degrading land. Some, such as Yara International, The Mosaic Company, Nutrien and Eurochem, depend upon sales within Brazil (38 per cent of Mosaic sales were in Brazil in FY2020) but would be able to protect themselves from the most severe financial impact of the extreme weather event or even profit from it. Indeed, larger companies can profit from poor harvests as this situation can lead to higher soft commodity prices, as farmers globally are incentivised to increase planting for the next season. Increased acreage leads to higher demand for fertiliser, causing prices to increase. Fertiliser companies typically benefit from higher fertiliser prices not linked to higher feedstock costs. CF Industries, a North American manufacturer and distributor of agricultural fertilisers, noted that its Earnings Before Interest, Taxes, Depreciation, and Amortisation (EBITDA) increased by $350m for every $25 increase in the cost of fertiliser, while Yara notes that every $10 hike in urea prices results in a $44m increase in EBITDA. For the company selected as a market proxy,[iii] the EBITDA increase was 40 per cent, and **a 2024 drought event would result in a valuation increase of 14 per cent.**

However, domestic fertiliser producers could be at risk. The Brazilian fertiliser industry is much more fragmented than the global market. Amongst these companies, those with significant exposure to areas where a material portion of land is degraded, such as the Bahia and Piaui regions, will likely be impacted negatively in an extreme weather scenario. In addition, companies at the high end of the cost curve (mostly located in Asia) will have to face additional competition from companies diverting their sales away from Brazil in the year in which the extreme weather event occurs. Although a lack of public data makes it more difficult to assess the impacts on smaller fertiliser companies, we deem it likely that the impact for such companies is much more negative than for large global fertiliser companies.

A positive outcome for some fertiliser companies is dependent upon the severity of the weather event. Multiple years of yield decline may result in material credit losses, working capital outflows and negative volume impacts. The ultimate impact also depends on the ability of companies to redirect volumes to other regions, which might not be possible if extreme weather patterns occur in different regions at the same time.

All in all, while the economic effects of extreme weather in the long run might be positive for some fertiliser companies, this is not necessarily the case for the whole sector. Small, family-owned-type companies with exposure to areas with significant degrading land seem vulnerable. These companies have an interest in educating their clients in ways to improve soil quality, as it would reduce their credit losses in the event of bad weather events. A final effect, which was highlighted during our interviews with industry

[iii] We chose a proxy using the following criteria: a company with global presence, relevant exposure to the region of analysis (EU 33% of sales, Brazil 27%, Asia 15%, US 11% of global sales as of 2020) and provider of inputs for the crops that experience price sensitivity.

participants, is that the enhanced vulnerability of smaller companies to extreme weather patterns likely leads to further industry consolidation, as these companies become easier Merger and Acquisition (M&A) targets due to relatively weaker balance sheets following extreme weather events – a dynamic that might not be in the best interest of local stakeholders.

Company B – Production

Farmers are amongst the most likely victims of extreme weather patterns. In particular, those operating on a high degree of degrading land are most at risk. Previous studies have found that the effects of droughts on yields can be twice as large on degrading land and are longer-lasting than those occurring on healthy soil. Based on these studies, we assume that a farm located on degrading land would suffer three years of 40 per cent yield loss as the result of an extreme drought, compared with one year of -10 per cent impact on yields for a farmer operating on healthy soil. Alongside this yield assumption, we incorporated assumptions on volumes, pricing and variable costs in the scenario.

- Volumes: drop of 40 per cent in years 1–3 for a farm operating on degrading land and 10 per cent in year 1 for a farm operating on healthy soil (this leads to an average impact in the geography of ~20 per cent, which is in line with research findings mentioned previously).
- Pricing: increases of 40 per cent in year 2 before normalising in year 3.
- Fertiliser costs: increase by 40 per cent in year 2.
- Variable costs: a farmer operating on degrading land is able to reduce variable costs to zero in year 2 and begin investing in land restoration projects halfway through year 3 in order to resume full production in year 4.

Following this scenario, our discounted cash flow (DCF) model indicates that **the impact on market value for a farm located on degrading land is equal to 16 per cent of its market capital**, meaning it is 16 per cent lower than if no drought event had occurred. This might seem a surprisingly low impact, but it can be explained by the assumption that variable costs would decline to zero in year 2. The line of reasoning behind this assumption is that the farmer would be unlikely to plant seeds on degraded soil and will only start investing in the land again when the soil is restored, which we assume to happen in year 4. Again, this might be simplistic as, in reality, farmers might try to accelerate the recovery of land by planting a temporary pasture. However, directionally we do not think taking one assumption or the other impacts the outcome.

It might also be the case that the yield loss would not recover after three years, making it uneconomical to resume operations at the farm as the land would be unproductive. Larger-scale businesses operating within EBITDA margins of around 25 per cent have found it difficult to maintain profitability in areas vulnerable to volatile weather. SLC Agricola, for example, began divesting land in the Bahia and Piaui regions following the severe drought of 2015/2016. Hence, it is likely that farms operating on degrading land will reach an economic tipping point if yields decline by more than 30 per cent for several years. Eventually, this would lead to more consolidation, as local farmers are acquired by larger ones who see the situation as an opportunity to gain market share, or supply shrinks indefinitely, as the land becomes uneconomic to farm.

Another factor not modelled is that a farming company that loses 40 per cent of its yield is likely to see its cost of capital increase. Our model shows that the farmer will have to take on additional debt in the year of the drought, which would lead to higher interest costs. This situation has the potential to lead to stricter payable requirements from clients. We have not modelled all of these factors as it is difficult to agree upon the impact with certainty; however, doing so might show the impact to be temporarily more severe for investors than the 16 per cent DCF impact we model.

On the other hand, **the impact of a drought event on a farm that operates on healthy soil is positive, with the DCF-determined market value increasing by 6 per cent**. Again, this might be counterintuitive. In our scenario, EBITDA in year 1 does decrease by 36 per cent as a result of significant yield reduction. However, it would recover in year 2 as a price increase of 40 per cent, coupled with recovered volumes, results in a record high EBITDA. This scenario is corroborated by historic events, such as in 2017, where the EBITDA of our proxy company grew by 220 per cent after a bad harvest in the 2015/2016 crop season.

All in all, smaller farms operating on degrading soil are most vulnerable to severe weather events. As a result, companies in the chain with exposure to these farms will also be impacted. It seems in the interest of both farmers and those who count farmers among their clients or suppliers to improve soil quality in order to reduce economic fragility. As in the fertiliser value chain, company representatives interviewed indicated that consolidation could be one of the effects of an extreme weather event. In previous La Niña years, large farming companies abandoned or sold farmland in high erosion areas as these farms had apparently reached an economic tipping point where it became unappealing to restore the land. Assuming opportunities for land expansion are limited elsewhere, due to new anti-deforestation efforts, for example, this dynamic could permanently reduce the land available due to poor soil quality.

Company C – Distribution

Trading companies have an important role to play within the agri-food supply chain, integrating processing and logistics capacity and linking farmers to the global marketplace. The business model of a trading company is based upon strategic asset ownership close to local production areas, combined with a global relationship network. Trading companies tend to have strong balance sheets and use their financial resources to finance suppliers in order to build a relationship.

Most trading companies have a global presence and diversify their logistics assets in different producing areas to avoid excessive exposure to crop risks. This means that in the event of a supply disruption in soft commodities in one region, they would be able to procure volumes in other markets. However, there are direct logistical costs involved with this that impact operating margins. In addition, due to their long-term relationships with farmers, they are likely to be incentivised to extend working capital facilities and increase financing to the affected farmers to help them stay in business until the next crop is produced. Again, it is highly likely that trading companies with significant exposure to farmers operating on degraded land are more exposed to these factors than those with clients who are less vulnerable to extreme weather patterns (i.e., those that operate on healthy soil).

The following assumptions were made for the scenario, as it relates to trading companies:

- <u>Revenues</u>: 72 per cent of the trading business relates to grains. The trading benefits from the 40 per cent soft commodity price spike in FY2025 in their revenue share, gaining 28 per cent. In

FY2026, if average soft commodity/fertiliser prices go back to yearlong average, the trading company would see its margins do the same.

- Working capital: in FY2024, if farmers had 10 per cent lower yields, the trading company's working capital would be impacted to the same proportion as their agribusiness trading line. For the company we took into consideration, their agribusiness division is 72 per cent of their total revenue share. That said, we applied an increase in working capital demands of 7.2 per cent for the 2024–2026 period as we would expect the farmers to fully recover after three years.
- Costs: the trading would have an increase in costs in FY2024, as the company would have to procure its crops elsewhere. Therefore, we consider 20 per cent higher transportation costs for the agribusiness division, or 14 per cent if applied to the total transportation costs. This scenario assumes transportation costs are 33 per cent of total costs. In FY2025, margins would increase due to gains from milling and storage in line with prices.

Following this scenario, our DCF model indicates a slight positive impact on the market value for the trading company, of +4 per cent of its market cap. One explanation for this positive impact is that trading companies have globally diversified operations, mitigating their risk exposure to local events. In addition, if operating on a global scale, these businesses have good access to credit supported by their strategic logistics assets. The model shows that the balance sheet burden and additional costs a global trader incurs due to a 10 per cent decrease in yields from selected suppliers can be offset by 40 per cent higher prices.

Whilst the impact may seem neutral, or even positive, for a global trading company, other variables can aggravate the scenario for the trading company, depending on its assets, size and location. Should the exercise be undertaken for a small local trading company, with operations in degraded areas, the impacts would be negative.

If the company experienced full exposure to the farmers on degrading land – those enduring 40 per cent yield loss – with limited capacity to procure elsewhere, then the negative impact on their fair value would see a 10 per cent fall in market cap. The reason for this change would be the additional burden of working capital and an inability to fully enjoy the higher prices in their impact revenues and margins, due to lower volumes procured.

The negative impact could be more severe: one of the trading companies interviewed agreed that balance sheet expansion with potential credit profile deterioration would be likely for those purchasing from farmers operating on degrading land. We have not modelled an increase in weighted average cost of capital (WACC) for these companies because the increase could be avoided if the company took prompt action to mitigate the land degradation trend to which it was exposed. For simplicity, mitigating actions were not modelled as these would be specific to the company in question and would make too many assumptions about company strategy. Unless mitigating action is taken, the higher WACC resulting from a credit profile deterioration would, in all likelihood, reduce the valuation even further for those trading companies with the most exposure to farmers with the highest yield losses.

Again, our findings highlight the importance of companies in the supply chain diversifying and educating their clients on soil management. Exposure to farms operating on degrading land creates spill-over risks which will be felt by local trading companies with significant exposure to degrading land in adverse scenarios such as those modelled.

Company D – Consumption

Food producers come in different shapes and sizes. With respect to this research, we looked at a packaged food production company active in sales of poultry and pork-based meat. Typically, such companies are vulnerable to extreme weather patterns. Difficulties in procurement of substitute products and transportation challenges impact their costs and operations. Depending on market conditions, food companies are unlikely to be able to fully pass on cost increases, and, as a result, their margins would fall during periods following extreme weather. These challenges would prove more severe for smaller companies, especially those sourcing from farms operating on degrading land. This is because they likely have less efficient procurement, yet must find replacements for the higher levels of inputs required (as yields from the farms where they source raw materials decline faster than those from farms operating on healthy land). Furthermore, these additional purchases would need to be procured on the spot market in a period when soft commodity prices are high due to the weak harvest.

In our scenario, we look at a packaged food production company which procures most of its animal feed from local producers impacted by the supply shock. For this company, around 70 per cent of their cost of goods sold (COGS) relates to raw materials and supplies. Of these, 14 per cent of total COGS relates to logistic costs (20 per cent of the total implied raw material costs).

The following assumptions were made for the scenario, as they relate to the food producer:

- Costs: assuming farmers in the company's supply chain had 10 per cent lower yields, the food company would have to increase costs by purchasing grain in a different location rather than through its usual supplier. Higher transportation costs would impact operating margins. An additional increase of 3.5 per cent in COGS is calculated, thus reducing the company's EBITDA.
- In FY2025–26, the company does not want to risk market share by fully passing the costs to its customers and so decides to absorb part of the cost increases. For our exercise, we consider they absorb one third of the cost increases and gradually pass through the rest.
- Through investment in grain storage capacity, when margins recover to pre-shock levels in 2026 the company could maintain margins slightly above the long-term average to retain some of the competitive advantage gains.
- Working capital: operating expenditure would need to be increased as the company needs to anticipate feed inventory and an increase in crop prices in 2025. Analysing the impacts of past price shocks in the working capital of the company, we noted their needs cause a twofold increase in the expected cost impact, or 7 per cent in this case. Working capital size does not recover fully, as the company incurs additional logistic investments to overcome the procurement disruptions. As a consequence, the company can reach the terminal year with lower return on invested capital.
- Revenue: in FY2025 and FY2026, the food company passes through one third of the 40 per cent grain price increase in 2025 and the other third in 2026. They do not pass through price changes in full. In 2027, prices would then return to normal levels.

Following this scenario, our DCF model indicates that **the negative impact on the market value for the food producer would be 24 per cent of its market cap**.

The price disruption in animal feed would impact the value in the food production industry in several layers. History has shown that these companies would not be able to pass through the full magnitude of the cost increase to begin with. In addition, working capital costs and needs increase, with cash and balance sheet impacts. In addition, the supply disruptions could result in additional logistic investments which are, generally speaking, permanent in nature. Finally, losing sales volumes and experiencing a deterioration in sales mix are likely side effects of price increases on consumer demand which we do not take into account in this exercise.

Interviews with food producers showed how difficult the volatility of commodity prices has made their daily business. Large food companies set up complete departments dedicated to tracing and monitoring supply chain disruption, with the aim of creating more predictability of supply and being able to move quickly when the next supply shock hits. One of the company representatives mentioned that their company has doubled the number of months in crop inventories over the past two years in order to better anticipate commodity price volatility.

The above sensitivity analysis, resulting in a market value decline of 24 per cent, is based on a global food producer company archetype. **When we run the scenario on a small local food producer with direct exposure to suppliers on degrading land, we found a negative impact in firm value of up to 45 per cent.** The increase in magnitude was because some grains, such as corn, depend upon logistics, and a breeding farmer could have difficulties in sourcing grains elsewhere due to capital shortage and logistic constraints. Compared to a multinational, they would also have limited resources to invest significantly in storage capacity.

The competitive advantage of large global companies over local producers therefore increases. Margins for small meat producers in an impacted region would not recover to pre-weather event levels; however, global businesses could afford to keep prices lower, as the impact on their cost structure would be less severe than that of the local operator, in particular for those sourcing from degrading land. Bearing in mind these difficulties, the cost of capital for a smaller company would also be higher, which is why we add 50 basis points to the cost of debt. This impact may appear exaggerated, but if a small breeding farmer encountered difficulties offsetting grain price increases and failed to procure enough for their breed, they could be obliged to reduce capacity or even close. It should not, therefore, come as a surprise that global food producers have previously increased market share to the detriment of small, family-owned businesses during periods of soft commodity supply shortages.

These findings illustrate how important it is for food producers to trace crop supply and evaluate risks related to how suppliers manage land. Those that fail to emphasise to their suppliers the importance of sustainable land management practices face greater risk.

In addition, the weaker position of the local producer points to the need for government policies that support smaller food producers. For example, having open-source, publicly funded solutions for soft commodity supply traceability could help smaller food producers access information about the state of the land from which they are sourcing, as well as facilitate the price signal between ethical consumers and those farming healthy soil.

Conclusions

This study found that **exposure to land degradation has a material impact on the economic value of companies across the agricultural chain**. Amongst those analysed, **listed companies with concentrated and sustained exposure to small-scale farmers operating on degraded land were most vulnerable to the economic impacts of extreme weather events**. Meanwhile, large corporates and those not farming or connected to degrading land could profit from extreme weather, for example by increasing their market share through M&A following a drought event.

Large farming businesses have also been found to retreat from areas more vulnerable to soil degradation, showing that land restoration following a drought might be more problematic than the model used assumes.

As the level of exposure to land degradation for many companies along the supply chain – and their investors – may be unknown, the analysis underscores how **it is in the interest of companies to improve supply chain traceability and ensure farmers invest in soil quality to reduce financial vulnerabilities and avoid company value from being at risk.**

The level of exposure to land degradation can also differ substantially across the value chain. Whilst large fertiliser businesses can see their value increasing as a result of higher global prices for their products, food producers (packaged food and breeding farmers) are confronted with higher working capital constraints and would find it difficult to pass through rising input costs to consumers. These can result in negative impacts on company value of 45 per cent.

There are significant differences as to how a stress test, such as a severe drought, impacts market values across sectors. In farming, for example, the model showed that farmers operating on degrading land are much more vulnerable to extreme weather events. Even under the moderate assumption that they can bring variable costs to zero, they are likely to lose 13 per cent of their market value as a result of a series of poor harvests.

Farmers with healthy soil, however, can gain market value because the initial harvests following extreme weather are not as poor as those on degrading land, and crop yields recover more quickly. These superior yields capture subsequent price increases.

Table 2: Overview of scenario results

Position in the value chain	Activity	Impact of scenario on market value (DCF basis)
Pre-production	Production of fertiliser	+14%
Production	Farming – Healthy Land	6%
Production	Farming – Degrading Land	-12%
Distribution	Global trading	+4%
Distribution	Local trading	-10%
Consumption	Global packaged food production company	-24%
Consumption	Local packaged food production company	-45%

In the stress scenario, the drought results in an inflationary impact that companies have difficulty overcoming, with implications for demand and profitability. **Farms located on degraded areas and food producers suffer the biggest falls in value**, with fertiliser companies displaying the most resilience. Amongst the economic effects identified were reductions in crop volume and profit margin, higher balance sheet risks, higher working capital needs and implications for the return on invested capital across the chain. Key risk mitigators identified are geographical diversification, scale and high-quality land management.

Size and access to capital can determine whether companies are able to continue to operate. Small producers will have difficulty due to chronic profitability deterioration and limited credit availability. Interviews with industry representatives identified **consolidation of assets and higher levels of integration as an increasing trend that will be amplified due to the deterioration of soil health**. This highlights how, for global companies, the most economical decision might be to leave areas where land quality is deteriorated in order to retain overall profitability levels and expand to other areas. This strategy can often come at the expense of native vegetation or cause overexploitation of producing fields, rather than an increase in sustainable land use and land recovery practices. Local players exposed to degradation, on the other hand, will have to bear the brunt of a negative impact in the short term. Despite this, **the acceleration of land degradation is a long-term risk that will impact the entire value chain, regardless of company size**.

The findings point to the need for government action to reverse nature loss. Excessive land use change and overexploitation of natural resources aggravate land degradation trends, increasing food security risks and further increasing the disparity between large corporations and small producers. Building sustainable and inclusive public policies to reverse land degradation trends offers the opportunity for local small producers to appropriately structure their businesses, creating more benefits to society. Mobilising resources for strategic land restoration projects can rebuild the productive capacity of soil and provide multiple economic, social and environmental benefits. Fostering sustainable farming practices, open access to soil data, pushing for innovation on land management and stimulating farmer education are effective ways to improve the resilience of the local farming and food supply chain – alongside sustainable strategies to avoid recurrent inflation derived from price shocks and caused by unpredictable crop yields.

In summary, **exposure to land degradation reduces the economic value of companies across the agribusiness value chain and is a material risk factor that needs to be considered by investors when investing in the sector**. Integrating land degradation as part of sustainability risk assessment within investment portfolios can protect future asset value for clients of investment managers. Consequently, **there is a need for investors to actively engage with companies and governments to understand what actions are being taken, and can be taken, to reduce the future risk associated with the degradation of land and its soils.**

Appendix

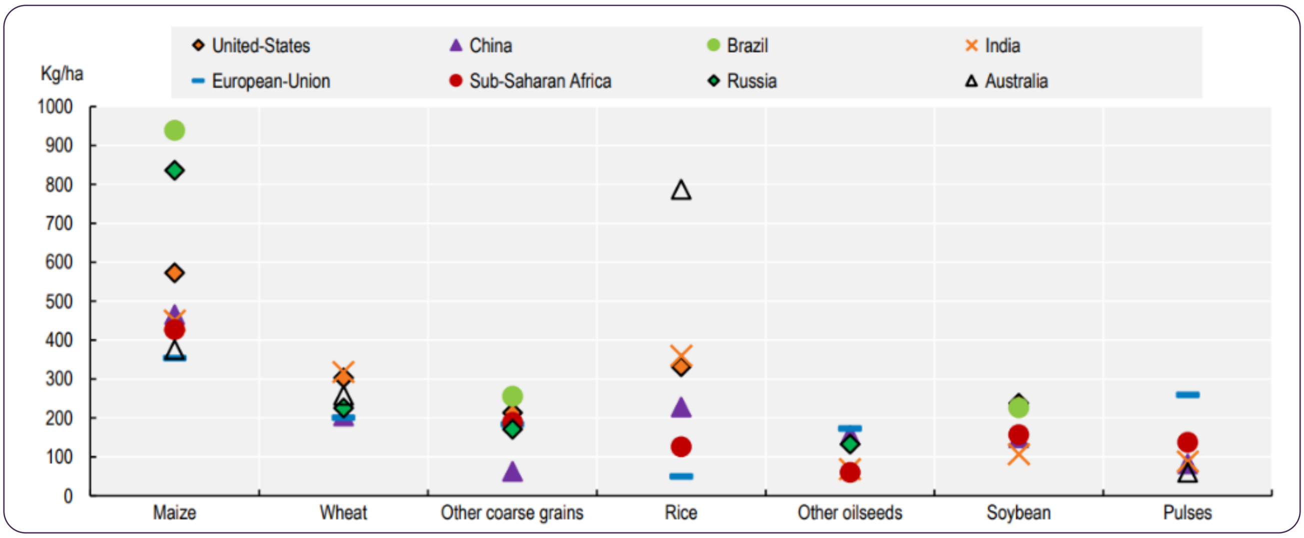
Appendix I: Brazilian agribusiness sector in figures

Aspects of the Brazilian agribusiness sector are degrading land across the country.

Brazil is one of the biggest global agricultural commodity producers (see Figures 1 and 2). Its production in the past years has grown rapidly due to the increasingly widespread application of yield-enhancing measures from intensive farming practices, in combination with favourable soil and climate conditions. Yet many Brazilian regions are experiencing an advanced process of desertification.[16] This type of land degradation is advancing in regions associated with deforestation, such as the Cerrado and Amazon biomes (see Figures 3 and 4), reducing air moisture and water flows. The replacement of native vegetation with crops also reduces sunlight absorption levels leading to increased temperatures.[17] Figures 5 and 6 highlight the incremental deforestation per km in the Amazon and Cerrado biomes.

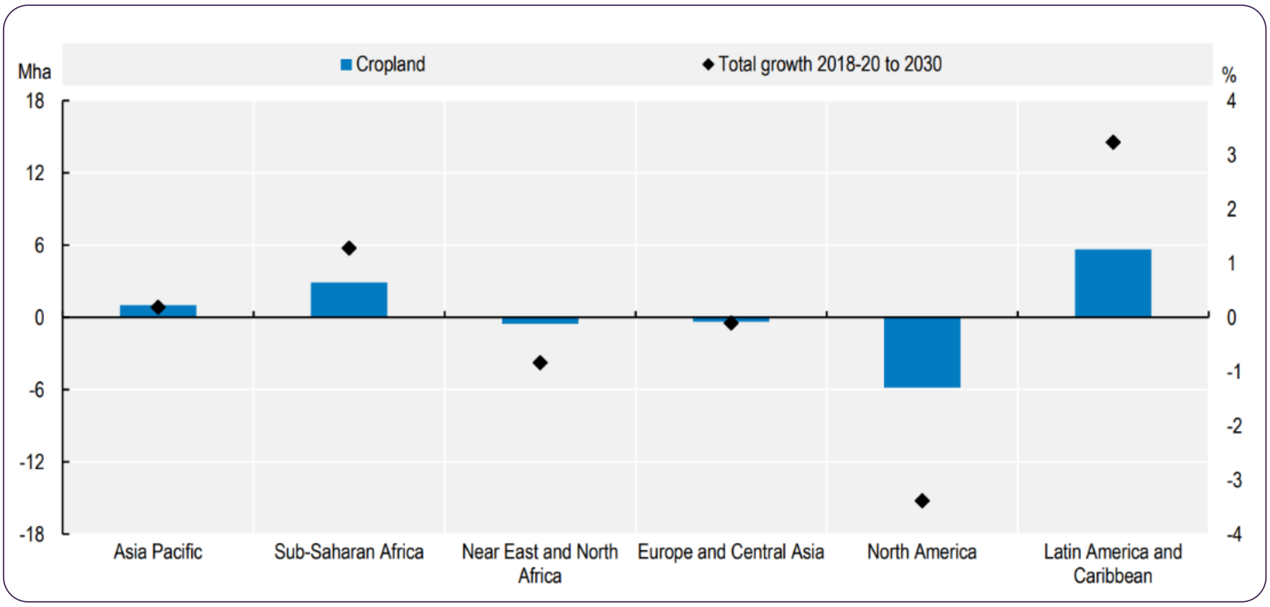
Figure 7 shows the location of the Brazilian Cerrado and its land use over decades. (a) represents biome limits; (b) intact Cerrado area in the state of Goiás; (c) cropland area in the west of the State of Bahia; and (d) land use evolution in the Brazilian Cerrado between 1985 and 2018.

Figure 1: Growth in projected yields for selected crops and countries from 2021–2030



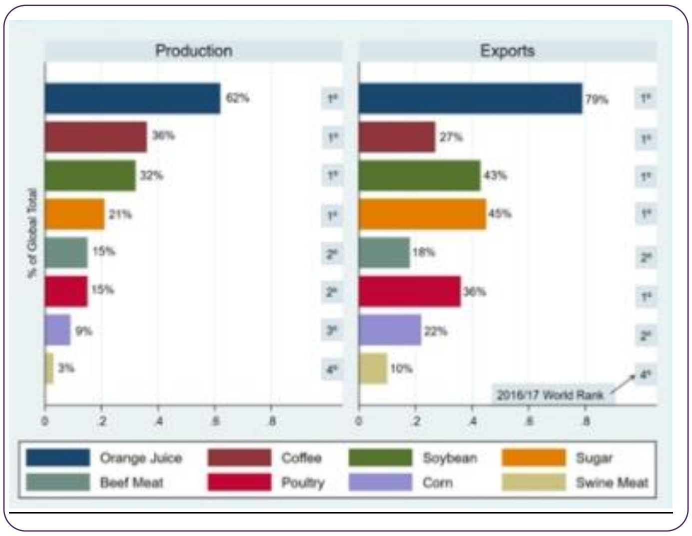
Source: OECD/FAO (2021), OECD-FAO Agricultural Outlook 2021–2030, FAO, Rome/OECD Publishing, Paris. https://doi.org/10.1787/19428846-en

Figure 2: Change in cropland 2018/20–2030



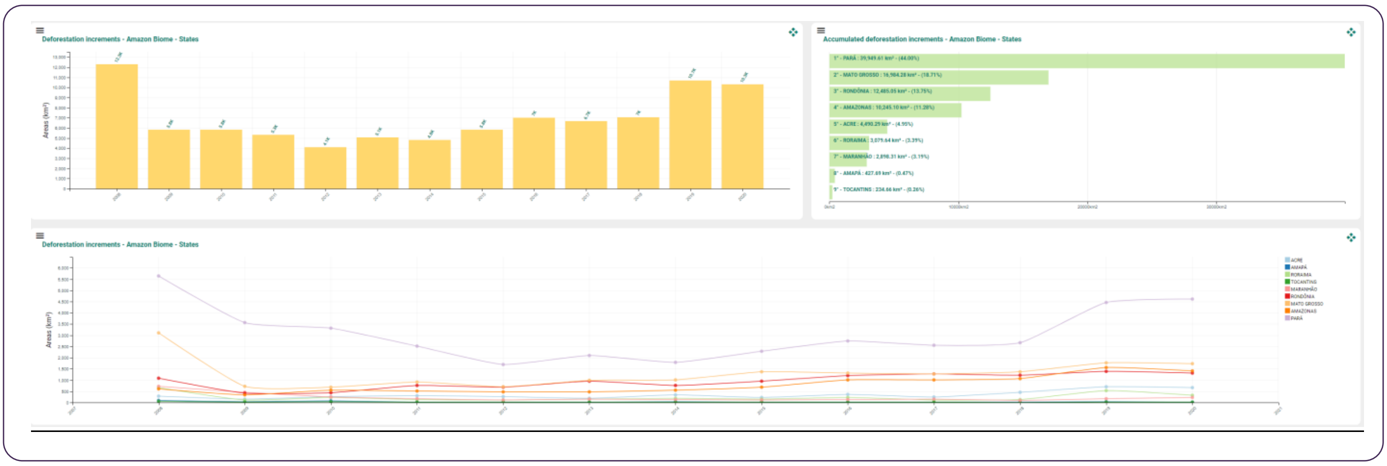
Source: OECD/FAO (2021), OECD-FAO Agricultural Outlook 2021–2030, FAO, Rome/OECD Publishing, Paris. https://doi.org/10.1787/19428846-en

Figure 3: Brazil market share and performance in global agricultural markets 2016–2017



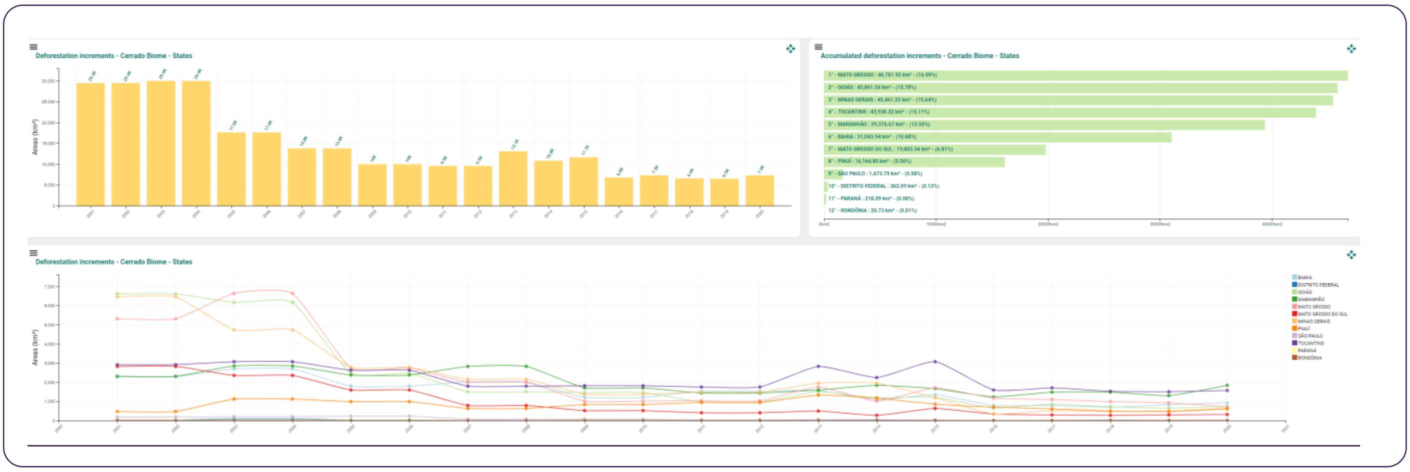
Sources: Calil, Y. C. D. & Ribera, L. (2019). Brazil's Agricultural Production and Its Potential as Global Food Supplier. Choices, 34(3), 1–12. https://www.jstor.org/stable/26964933; US Department of Agriculture, 2018 https://www.ers.usda.gov/topics/international-markets-us-trade/countries-regions/brazil/

Figure 4: Deforestation in the Amazon biome



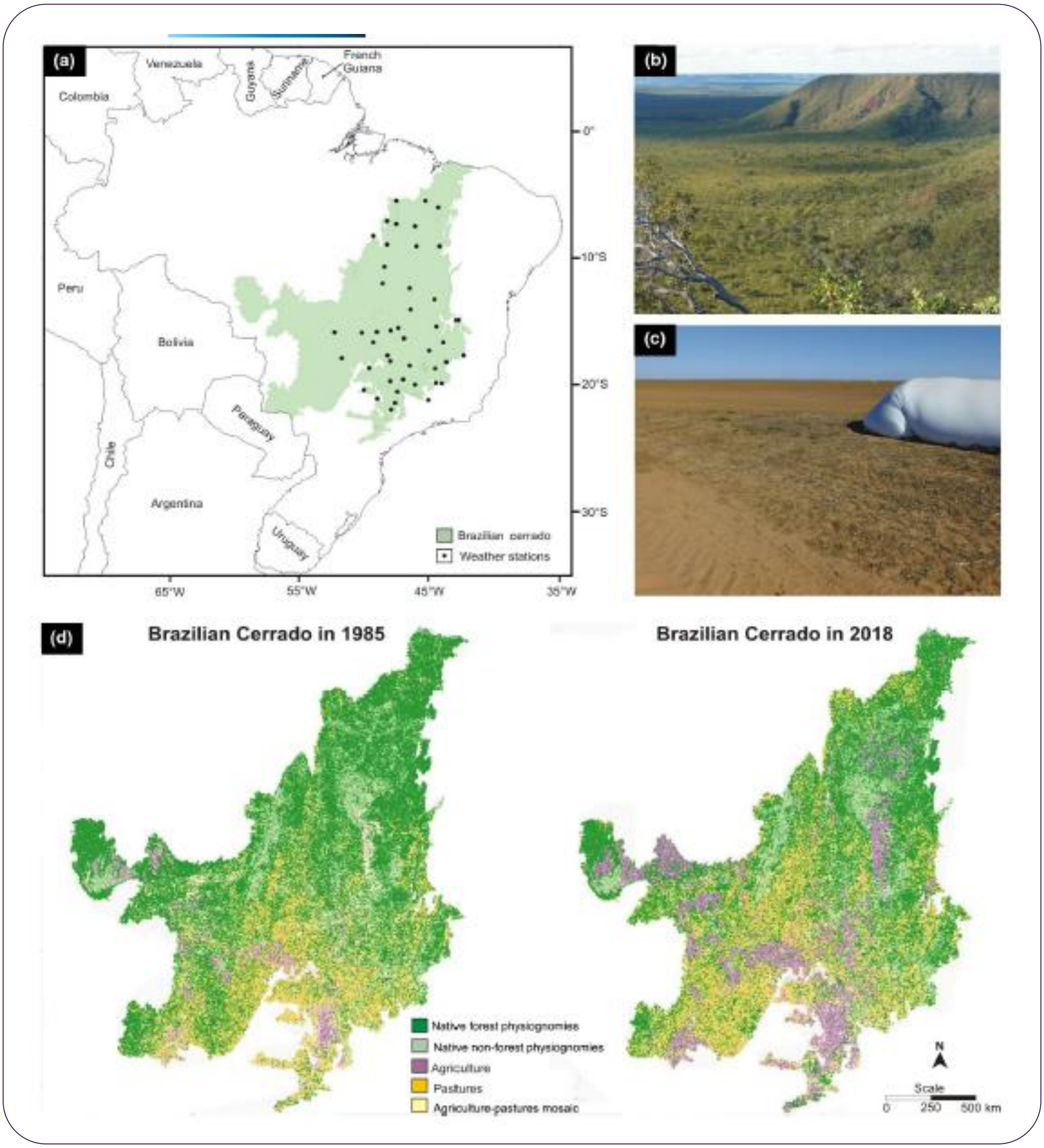
Source: Instituto Nacional de Pesquisas Espaciais (2021), PRODES deforestation dashboard.
http://terrabrasilis.dpi.inpe.br/app/dashboard/deforestation/biomes/amazon/increments

Figure 6 : Deforestation in the Cerrado biome



Source: Instituto Nacional de Pesquisas Espaciais (2021), PRODES deforestation dashboard.
http://terrabrasilis.dpi.inpe.br/app/dashboard/deforestation/biomes/amazon/increments

Figure 7: The Cerrado biome



Sources: Hofmann, G. S., Cardoso, M. F.,Alves, R. J. V., Weber, E. J., Barbosa, A. A., de Toledo, P. M., Pontual, F. B., Salles, L. D. O., Hasenack, H., Cordeiro, J. L. P., Aquino, F. E., & de Oliveira, L. F. B. (2021). The Brazilian Cerrado is becoming hotter and drier. Global Change Biology, 00, 1–14. https://doi.org/10.1111/gcb.15712*; MapBiomas – Collection 4.1 of Brazilian land use land cover map series on 28/12/2019,* https://mapbiomas.org/

Appendix II: Full assumptions and model outputs

For reference, the assumptions and model outputs behind the market risk figures cited are outlined below.

Table 1: Overview of model choices fertiliser archetype

Assumptions	Base Case	Stress case	Impact
Revenue growth	30.5% in 2021 -0.9% in 2022 -8.9% in 2023 1.5% in 2024–2031	30.5% in 2021 -0.9% in 2022 -8.9% in 2023 25% in 2024 -10.8% in 2025 1.5% in 2026–2031	
EBITDA mg	17.8% in 2021 17.8% in 2022 15.4% in 2023 14.5% in 2024–2031 normalised	17.8% in 2021 17.8% in 2022 15.4% in 2023 17.7% in 2024 14.5% in 2025–2031	
Equity NPV	USD 14.7bn	USD 16.6bn	USD 1.9bn
WACC	7.6%	7.6%	
DCF upside as of 04/10/2021	13%	27%	+14%

Table 2a: Overview of model choices farming archetype company on degrading land

Assumptions	Base Case	Stress case	Impact
Revenue growth	18.5% in 2021 27.3% in 2022 4.5% in 2023–2031	18.5% in 2021 27.3% in 2022 4.5% in 2023 -40% in 2024 40% in 2025 -28.5% in 2026 98% in 2027 4.5% in 2028–2031	
EBITDA mg	37.2% in 2021 36.7% in 2022 25.4% in 2023 25.4% in 2024–2031 normalized	37.2% in 2021 36.7% in 2022 25.4% in 2023 -23.3% in 2024 32.4% in 2025 -5% in 2026 25.4% in 2027–2031	
Equity NPV	USD 12.9bn	USD 11.8bn	USD 0.9bn
WACC	7.6%	7.6%	
DCF upside as of 04/10/2021	37%	25%	-12%

Table 2b: Overview of model choices farming archetype company on healthy soil

Assumptions	Base Case	Stress case	Impact
Revenue growth	18.5% in 2021 27.3% in 2022 4.5% in 2023–2031	18.5% in 2021 27.3% in 2022 4.5% in 2023 -10.0% in 2024 55.5% in 2025 -18.5% in 2026 4.5% in 2027–2031	
EBITDA mg	37.2% in 2021 36.7% in 2022 25.4% in 2023 25.4% in 2024–2031 normalised	37.2% in 2021 36.7% in 2022 25.4% in 2023 18.1% in 2024 41.2% in 2025 25.4% in 2026–2031	
Equity NPV	USD 12.9bn	USD 13.4bn	USD 0.5bn
WACC	7.6%	7.6%	
DCF upside as of 04/10/2021	37%	43%	+6%

Table 3a: Overview of model choices global trading archetype company

Assumptions	Base Case	Stress case	Impact
Revenue growth	33.6% in 2021 -1.4% in 2022 1.5% in 2023–2031	33.6% in 2021 -1.4% in 2022 1.5% in 2023-2024 28.8% in 2025 -20% in 2026 1.5% in 2027–2031	+ USD 15.35bn in 2025
EBITDA mg	4.3% in 2021 3.9% in 2022 3.5% in 2023 3.3% in 2024–2031 normalised	4.3% in 2021 3.9% in 2022 3.5% in 2023 3.1% in 2024 3.9% in 2025 3.3% in 2026–2031	(USD 75.2mn) in 2024 + USD 441.5mn in 2025
Average WC as % of revenue	9.2% normalised	9.8% in 2024–2026 9.2% in 2027–2031	(USD 451mn) in 2024 (USD 828mn) in 2025 + USD 1.51bn in 2026
WACC in USD	6.3%	6.3%	
Equity NPV	USD 14.78bn	USD 14.03bn	USD 385mn
DCF upside as of 22/10/2021	20%	24%	+4%

Table 3b: Overview of model choices local trading archetype company

Assumptions	Base Case	Stress case	Impact
Revenue growth	33.6% in 2021 -1.4% in 2022 1.5% in 2023–2031	33.6% in 2021 -1.4% in 2022 1.5% in 2023–2024 17.3% in 2025 -12.2% in 2026 1.5% in 2027–2031	+ USD 15.35bn in 2025
EBITDA mg	4.3% in 2021 3.9% in 2022 3.5% in 2023 3.3% in 2024–2031 normalised	4.3% in 2021 3.9% in 2022 3.5% in 2023 3.1% in 2024 3.5% in 2025 3.3% in 2026–2031	(USD 75.2mn) in 2024 + USD 441.5mn in 2025
Average WC as % of revenue	9.2% normalised	11.7% in 2024–2026 9.2% 2027–2031	(USD 451mn) in 2024 (USD 828mn) in 2025
WACC in USD	6.4%	6.4%	
Equity NPV	USD 14.9bn	USD 13.7bn	(USD 1.2bn)
DCF upside as of 22/10/2021	20%	10%	-10%

Table 4a: Overview of model choices global food producer archetype company

Assumptions	Base Case	Stress case	Impact
Revenue growth	16.7% in 2021 5.2% in 2022 6.2% in 2023 4.5% in 2024–2031	16.7% in 2021 5.2% in 2022 6.2% in 2023 4.5% in 2024 13.3% in 2025 13.3% in 2026 -18% in 2027 4.5% in 2028–2031	+ BRL 4.75bn in 2025 + BRL 10.3bn in 2026 (BRL -4.73bn) in 2027
EBITDA mg	11.4% in 2021 11.8% in 2022 12.5% in 2023–2031 normalised	11.4% in 2021 11.8% in 2022 12.5% in 2023 12.1% in 2024 11.7% in 2025 12.8% 2026–2031	(BRL 217mn) in 2024 + BRL 107mn in 2025 + BRL1.51bn in 2026 (BRL 819mn) in 2027
Average WC as % of revenue	5.6% normalised	5.6% in 2021–2023 7.0% in 2024–2026 6.3% in 2027–2031	(BRL 930mn) in 2024 (BRL291mn) in 2025 + BRL647mn in 2026
WACC in BRL	9.6%	9.6%	
Equity NPV	BRL 31.1bn	BRL 26.4bn	(BRL 4.1bn)
DCF upside as of 22/10/2021	67%	43%	-24%

Table 4b: Overview of model choices local food producer archetype company

Assumptions	Base Case	Stress case	Impact
Revenue growth	16.7% in 2021 5.2% in 2022 6.2% in 2023 4.5% in 2024–2031	16.7% in 2021 5.2% in 2022 6.2% in 2023 4.5% in 2024 10.0% in 2025 13.3% in 2026 -13.5% in 2027 4.5% in 2028–2031	+ BRL 4.75bn in 2025 + BRL 10.3bn in 2026 (BRL -4.73bn) in 2027
EBITDA mg	11.4% in 2021 11.8% in 2022 12.5% in 2023-2031 normalised	11.4% in 2021 11.8% in 2022 12.5% in 2023 12.1% in 2024 11.7% in 2025 12.8% in 2026 12.1% in 2027–2031	(BRL 217mn) in 2024 + BRL 107mn in 2025 + BRL1.51bn in 2026 (BRL 819mn) in 2027
Average WC as % of revenue	5.6% normalised	5.6% in 2021–2023 6.4% in 2024–2026 6.1% in 2027–2031	(BRL 930mn) in 2024 (BRL291mn) in 2025 + BRL647mn in 2026
WACC in BRL	9.6%	9.7%	
Equity NPV	BRL 31.1bn	BRL 23.1bn	(BRL 8.0bn)
DCF upside as of 22/10/2021	67%	24%	-43%

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