Zero Carbon Analytics

Briefing

Deforestation in Brazil's Cerrado reduces soy production and threatens supply chains

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Key points

- Brazil's tropical savanna – or Cerrado – has faced extensive clearing of native vegetation in recent decades, largely for soy production. Agricultural expansion leads to drying, which reduces productivity. This drives farmers to clear more land, further accelerating degradation.
- Our new analysis found that when farmers clear native vegetation for soy, the climate impacts extend far beyond the cleared plots. These reduce yields at the regional scale and outweigh the gains from new farmland by 3:1. However, individual farmers who clear land still profit from their expansion, revealing a critical challenge for conservation policy.
- Based on our calculations, if no land had been cleared for soy in the Cerrado since 2008, the region would have produced an additional USD 9.4 billion of soy – nearly 8% of the region's soy output between 2013 and 2023.
- Even more modest land conservation shows benefits. Avoiding just 10% of Cerrado clearing would have generated almost USD 1.0 billion in additional production. A 25% avoidance would have generated USD 2.35 billion, and a 35% avoidance would have generated USD 3.29 billion.
- Importers' supply chains are heavily exposed to regions damaged by clearing. China faces the biggest absolute threat, sourcing from areas where clearing has destroyed USD 5.0 billion of annual soy production capacity over 2013-2023, followed by Spain, the Netherlands and Germany.
- However, Germany's soy imports are concentrated in actively high-clearing municipalities. Each tonne Germany imports is linked to more local production loss than other buyers. Implementing deforestation-free supply chain measures could protect soy productivity – every million tonnes that Germany shifts toward zero-deforestation suppliers would preserve USD 43 million in regional productivity.

- EU supply chains sourcing from recently cleared areas face non-compliance risks under EU regulations prohibiting imports from regions deforested since 2020. France, Romania and Portugal may be particularly exposed.
- Brazil – and soy-importing countries – face a critical window for action. We find a threshold below which vegetation protection delivers maximum climate benefits. Nearly every actively-clearing municipality still retains this advantage.

Soy-driven mass deforestation in the Cerrado is reducing regional rainfall

- Unprotected by policy, almost half of the Cerrado - a drought-resistant biome - has been cleared for agriculture, according to peer-reviewed research.
- Scientific studies show that deforestation in thai region reduces rainfall across the continent, worsening the effects of climate change.
- New modelling indicates that yields from the growth in soy farming in the Cerrado are undermined by the climate impacts of deforestation.

Brazil's tropical savannas, locally known as the *cerrado*, are the country's second-largest biome after tropical forests. The Cerrado includes grasslands, woodlands and Brazil's upside-down forest, an extensive underground root system that stores more than five times the carbon found in its above-ground vegetation. This remarkable root network enables plants to survive droughts and fires by accessing deep water sources and nutrients stored below the surface.

In recent decades, the region has faced extensive clearing of native vegetation for agriculture. At least 46% of the Cerrado's native vegetation has been cleared for pasture or crops. Brazil is the world's largest producer and exporter of soy, which accounted for 14.5% of total exports between January and September 2025.[1] Soy is also the second-largest direct driver of deforestation in Brazil, after cattle ranching.

The Matopiba region, an acronym for the Maranhão, Tocantins, Piauí and Bahia states, is considered the Cerrado's newest 'agricultural frontier'. Here, farming is expanding into previously uncultivated land. The soybean area increased by 253% between 2000 and 2014, at the expense of 50% of the region's native vegetation.

In 2023, deforestation in the Cerrado reached 1.1 million hectares – more than twice that of the Amazon in the same year. Rates have eased more recently, though deforestation

[1] Comex Stat database, accessed 31 October 2025.

continues. Despite the extent of deforestation in the Cerrado, the region has been overlooked in environmental policies.[2]

Deforestation intensifies drought, which undermines soy production

Locally, clearing land interrupts evapotranspiration, undermining the Cerrado's natural moisture recycling system and worsening heat stress. At a regional level, replacing native vegetation with cropland significantly alters the climate by disrupting the systems that carry moisture to Brazil and neighbouring countries, known as climate teleconnections (Box 1). As a result, land use change in the Cerrado impacts rainfall across South America.

Average annual evapotranspiration in the Cerrado decreased by approximately 44% from 2006 to 2019, while temperatures increased by around 3.5°C. Less evapotranspiration means the air holds less moisture, leading to fewer clouds and less rain. This, in turn, makes the land dry, causing a positive feedback loop.

The region experienced an unprecedented drought in 2024, which a scientific attribution study has confirmed would have been impossible without human-caused climate change, exacerbated by deforestation.

Box 1: How does deforestation impact rainfall?

As well as supporting biodiversity and sequestering carbon, forests regulate the Earth's climate by maintaining its temperature and fresh water flows.

Forests move water in a process called **evapotranspiration**:

- Trees draw up groundwater through their roots
- Moisture is released back into the atmosphere through treeleaves
- The released water turns into clouds and falls as rain.

This creates a natural cooling system. Plants recycle 80–90% of rainfall back into the air in a feedback loop that sustains the global water cycle and cools the planet.

The water vapour generated by trees is carried by atmospheric currents and creates rainfall both locally and further away. This kind of long-distance climate link is called a **teleconnection**.

Deforestation disrupts this natural system, as evapotranspiration cannot take place when trees are cleared. Plus, without the cooling effect of evaporation, the

[2] The study's authors attribute the Cerrado being overlooked in the Soy Moratorium to "differences in public awareness, national politics and narratives, changes in trade relationships, leadership and sunk investments".

solar energy that would normally drive evapotranspiration creates hot, low-pressure zones that alter regional wind patterns. In some parts of the world, losing a forest-rainfall teleconnection may present a "more imminent threat even than global warming".

The Amazon's 'flying rivers' are a well-known example of a forest-rainfall teleconnection. Less-studied but equally important teleconnections exist in the Congo Basin in Central Africa, which contains the world's second-largest tropical rainforest, and in Brazil's Cerrado.

In the Southern Brazilian Amazon – a soy cultivation region bordering the Cerrado – deforestation has been shown to reduce rainfall, shortening the growing season and undermining the region's soy and beef production, which is largely rain-fed. A 2021 study estimated that if weak deforestation policies continue in the region, soy and beef revenues could fall by an estimated USD 186 billion by 2050. This dwarfs the profits that would be lost by conserving forests under stronger governance – around USD 19.5 billion.

A recent modelling study across five states in the Amazon and Cerrado showed that if deforestation-induced disruptions to rainfall hadn't occurred since the early 1980s, soybean yields would have been about 6.6% higher annually between 2011 and 2020.[3] This is despite improved agricultural efficiency during that time, emphasising the overwhelming negative effect of altered rainfall on yields.

New analysis shows deforestation in the Cerrado negatively impacts Brazilian agricultural productivity

- A new data analysis shows that drier conditions caused by deforestation in the Cerrado are damaging the region's soy yields.
- Data spanning 10 years indicates that soy profits would have been greater overall if there had been less deforestation in the Cerrado.
- Limiting forest clearing delivers stronger agricultural growth than pursuing it.

New Zero Carbon Analytics analysis explored whether the drying caused by clearing land to plant more soy creates hidden productivity losses that counteract the benefits of

[3] The study is comparing yields on farms between (a) a scenario where deforestation did not reduce regional rainfall and (b) the present scenario where deforestation has reduced rainfall. The yield gap represents the lost productive potential of the current agricultural system due to the climate change that the system itself helped cause.

expansion. We explored this using Trase Earth data on soy production, yield, exports and price from 840 municipalities in the Cerrado between 2013 and 2023, and combined this with rainfall and aridity data.[4]

Trase defines soy deforestation as "the soy area in the target year that overlaps with deforestation… in the five years prior to soy detection." Given our study period of 2013-2023, this means our deforestation data captures forest loss from 2008 onwards (the five years before our earliest observation year) through 2022.

The Cerrado region would have produced 8% more soy from 2013-2023 without deforestation

Our analysis shows that soy-driven deforestation in the Cerrado is making the region drier.[5] Greater soybean clearing was found to have dried out the local moisture balance in all municipalities since 2008. Areas with more vegetation loss experienced more arid conditions, confirming scientifically what farmers often observe anecdotally: clearing trees leads to less rainfall and moisture locally.

If no land had been cleared for soy in the Cerrado since 2008, our calculations show that the region would have produced an additional USD 9.4 billion of soy – equivalent to nearly 8% of the region's soy output over the study period.[6]

We also calculated the amount of soy that would have been produced if 10%, 25%, 35% and 50% less land had been cleared for soy, giving an indication of the production benefits of conserving the Cerrado. Avoiding just 10% of clearing across our study region would have generated an additional USD 938.8 million of soy between 2013 and 2023, implying

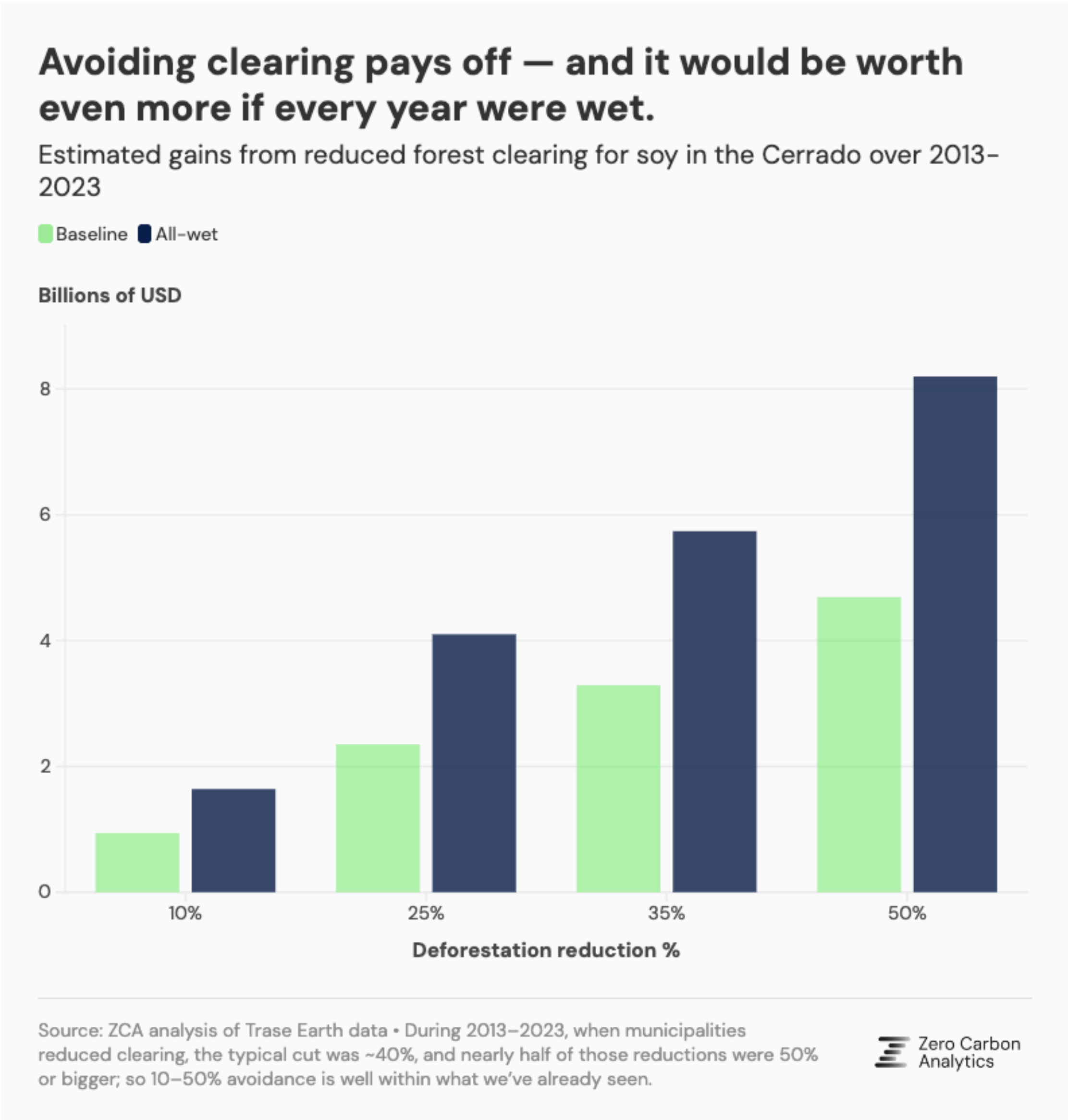
[4] We used CHIRPS v3.0 rainfall maps to calculate the average annual rainfall at a spatial resolution of 0.05 degrees for each Brazilian municipality (2013–2023) by overlaying the rasters on official municipality boundaries and averaging the values inside each polygon. We then calculated anomalies relative to each municipality's 1991–2020 baseline (we followed the World Meteorological Organisation (WMO) definition of climatological standard normals of 30-year averages, using the current 1991–2020 normal as baseline). Our aridity index, the standardised precipitation evapotranspiration index (SPEI), was based on monthly precipitation and potential evapotranspiration data from the Climatic Research Unit of the University of East Anglia at a spatial resolution of 0.5 degrees. Annual average values were calculated for each municipality for each year.

[5] To assess land clearing's impact on local aridity, we compiled panel data of municipalities in the Cerrado with yearly measurements of climate (SPEI, precipitation anomalies, see footnote 4) and land-use (land cleared for soy). Each municipality has repeated annual observations, which creates a hierarchical data structure (years nested within municipalities). We employed a linear mixed-effects model fit by restricted maximum likelihood (REML) to leverage this structure, as it appropriately accounts for the non-independence of observations from the same municipality. This approach allows each municipality to have its own baseline (random intercept) while estimating the overall effects of clearing and climate on aridity. We performed extensive diagnostic checks to ensure the reliability of the mixed-effects model. The model converged with REML criterion = 493.5. Together, our fixed predictors explain nearly half of the variation in SPEI (marginal R^2 = 0.488), and incorporating municipality-level random effects raises explained variance to over two-thirds (conditional R^2 = 0.682), indicating that both clearing and local heterogeneity account for a substantial portion of SPEI variability. Greater soybean clearing systematically dries out the local moisture balance (SPEI) across all 840 municipalities.

[6] Based on the 72% of municipality-years for which trade price data is available.

that nearly USD 1 billion of additional soy could have been produced if modest conservation actions were put in place (Figure 1).

Figure 1



More ambitious conservation scenarios could have resulted in proportionally larger benefits: avoiding 25% of clearing would have preserved USD 2.35 billion in additional agricultural value, while avoiding 35% preserved almost USD 3.29 billion.[7]

[7] We looked at every municipality, year by year, and recorded how much cerrado was cleared for soy each year. For each location, we compared each year to the previous year and flagged it as a "reduction year" only when clearing went down (and the previous year had some clearing). For reduction years, we calculated the percent cut as "last year's clearing minus this year's, divided by last year's". The dollar figures we report are modeled gains calculated by estimating the tonnes of production "saved" by avoiding clearing (using our

These targets are realistic – municipalities in our dataset that see reduced clearing between 2008 and 2022 cut expansion by 56%, on average. Almost all (91%) of these municipalities maintained or increased production, demonstrating that reducing clearing does not limit output in the vast majority of cases.[8]

Intensifying existing cropland or adopting agroforestry may be better options economically than clearing more land. Better seed, improved land management, double-cropping, and integrating trees (e.g. windbreaks, alley cropping) can improve yield and stabilise local moisture.

Losses were twelve times worse in wet years than in dry years

The impacts of clearing vary dramatically with weather conditions.[9] During wet years with above-normal rainfall, we found that clearing 1,000 hectares for expansion caused regions to lose 14,627 tonnes of soy production. During dry years, the same clearing caused only 1,213 tonnes of lost production – a 12-fold difference.

This pattern is counterintuitive but might be explained by a critical mechanism: during wet years, when farmers expect higher yields, cleared land cannot retain the extra rainfall that should boost productivity, while forested areas capture and store it.[10,11]

The extreme losses from a single wet year could wipe out multiple years of profits from expansion. These findings also suggest that traditional economic models that use average impacts may severely underestimate the actual financial risks of land clearing.

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production-loss-per-kilohectare coefficient) and multiplying by the observed municipality-year prices, then summing across years. These are gross revenue numbers (they don't subtract conservation costs) and assume behaviour doesn't shift elsewhere. When we show an "all-wet" version, it's the same calculation valued with the wet-year penalty.

[8] To assess feasibility, we compared clearing rates and production levels between early (2013-2017) and recent (2018-2023) periods for each municipality in our sample. Among the 311 municipalities (51% of the sample) that reduced clearing between these periods, we calculated the percentage change in both clearing rates and production to determine whether output was maintained

[9] In our model, the interaction term (soy clearing × relative anomaly) allows the effect of land clearing on SPEI to depend on climate conditions. This tests whether clearing impacts are amplified during extreme wet or dry years. The negative clearing × anomaly interaction result in our model means that clearing has a stronger drying impact in anomalously wet years, when cleared landscapes lose moisture more rapidly, while in already dry conditions the marginal loss per hectare is smaller.

[10] Our panel models are associational. The inference that clearing reduces local moisture availability is consistent with the negative SPEI association and robustness checks (municipality and year fixed effects, clustered standard errors, exclusion of top-decile municipalities), but we do not claim causal identification and cannot fully rule out time-varying confounders (such as technology or infrastructure upgrades).

[11] Results are not driven by the very largest municipalities: excluding the top decile by soy area leaves the wet-year interaction negative and slightly larger in magnitude (−0.00612 to −0.00661). A stricter municipality fixed-effects model confirms the main drying effect but renders the interaction statistically weaker; we therefore emphasise the robust drying result and present wet-year amplification as a sensitivity consistent with the mixed-effects specification.

Farmers may profit from land clearance, but climate outcomes overwhelm these gains regionally, creating productivity losses

- Access to newly cleared land may benefit individual farmers, but a 10-year data analysis shows the climate impacts of clearances cause significant loss at the municipal level.
- Evidence backs conservation as a sustainable and profitable approach to soy farming; an approach which buyers could incentivise Cerrado farmers to support.
- Strategically intensifying farming practices has been proven to deliver greater soy yields without expanding agricultural land.

Our analysis revealed a paradox: land clearing for soy is profitable for individual farmers, but economically destructive at the regional level. At the municipal scale, clearing native vegetation created a 3:1 productivity loss between 2013 and 2023 – for every tonne of soy produced on new land, three tonnes were lost from existing fields due to climate spillovers.[12]

Yet, individual farmers still profited because they externalised most spillover costs: they captured all gains from their cleared land while losses were distributed across all farms in the municipality, proportional to farm size (see Box 2).[13]

[12] To do this, we built a municipality-by-year panel for 2013–2023 with (i) total soy production in each municipality and (ii) soy-driven clearing accumulated over the prior five years. We then compared years within the same municipality, controlling for municipality traits that don't change over time and for shocks common to all municipalities in a given year. This tells us whether years with more recent clearing ended up with higher or lower total municipal production. Because the outcome is total production, the estimated effect automatically nets the output from new fields and any spillover losses (or gains) on existing fields – i.e., it's a net effect per 1,000 hectares cleared. For dollar figures, we convert the implied tonnes using the observed municipality-year Free On Board (FOB) prices. We report standard errors that allow for correlation within municipalities (and years) and show robustness to outliers and to wet/dry conditions.

[13] Illustrative area-to-tonnes conversions assume 3 t/ha for newly cleared soy area (close to the panel median yield). Substituting the observed median yield leaves conclusions unchanged and only rescales the illustrative totals. All tonne-to-USD conversions use municipality-year volume-weighted FOB prices.

Box 2: An individual farmer scenario

Individual farmers may view land clearing as profitable, yet unknowingly be participatin in a system that reduces their own long-term economic returns.

Consider a soy farmer who expands their operation from 500 to 600 hectares by clearing 100 hectares of cerrado. From this new land, the farmer expects to produce about 300 additional tonnes of soy annually. If soy is priced at, say, USD 400 a tonne, they would expect to generate USD 120,000 in extra revenue each year.

However, our analysis shows that, on average, clearing 100 hectares reduces total municipal soy production by 837 tonnes annually through climate spillover effects. If the farmer's 600-hectare operation is part of, say, 10,000 hectares of soy farmland in the municipality, the farmer bears roughly 6% of these regional losses – about 50 tonnes annually on their existing 500 hectares, or USD 20,000 in lost revenue each year.

The farmer gains 300 tonnes and loses 50 tonnes annually on average – a net gain of 250 tonnes.

The extreme risk of wet years: In a single particularly wet year, spillover losses could potentially wipe out multiple years of expected gains. Our analysis reveals that during wet years – when farmers may expect their best profits – the same 100 hectares of clearing costs the municipality 1,452 tonnes in lost production. The farmer's 6% share of this loss equals 87 tonnes, worth USD 34,800 in a single year. During dry years, losses drop to just 7 tonnes, worth USD 2,700.

The financial reality: Over a decade with an equal amount of wet and dry years, losses would total USD 187,400. These losses would reduce the farmer's expected returns over the decade by USD 1,012,60, or 16%.

Short-term gains vs. long-term losses are a challenge for conservation policy

Studies of farmer attitudes in the Cerrado state of Tocantins and the Matopiba agricultural frontier found that farmers were sceptical toward zero-deforestation policies, with producers expressing concerns about external interference and questioning the motivations behind conservation. Interviews with soy producers in Matopiba found that their decision-making tended to be economically motivated, clearing land when profitable opportunities arose and in anticipation of future restrictions. This resistance reflects tensions between local autonomy and external regulatory frameworks, as well as legitimate concerns about economic impacts on rural communities.

These studies reveal a challenge for sustainability initiatives, which often struggle to compete with the immediate profit seen from expansion. Farmers resist conservation measures because they view them as costly, yet deforestation ultimately reduces agricultural profitability for the region. Changing perspectives – from seeing conservation as limiting agricultural profit to recognising that it can enhance it – requires evidence that demonstrates the financial benefits of conservation-compatible development and for the evidence to be communicated in a way that speaks to individual farmers' priorities and experiences.

Strategically intensifying existing farmland using improved technology and management practices offers the potential for better agricultural returns compared to continued expansion. The Amazon Soy Moratorium – an agreement whereby traders avoid purchasing soy from areas deforested after 2008 – demonstrated that soy can expand without driving deforestation and may, in fact, be more profitable in the long term.

Deforestation-linked risks to global soy supply chains create an economic case for conservation among key import markets

- Assessment of the global soy market shows that unsustainable farming practices in Brazil - the world's leading exporter - will have a global impact.
- Import statistics show that China and the EU could face price rises if the Cerrado soy yield is not sustainably protected.
- Countries most reliant on Cerrado soy can protect supply chains by investing in conservation or backing forest-positive suppliers, with collective action likely to prove most effective.

Soy production is heavily concentrated in three regions globally: 40% of soy is from Brazil, 28% is from the US and 12% is from Argentina. This means the global soy trade is tightly interconnected. There is limited flexibility for importers to switch suppliers without displacing other buyers.

Current patterns of soy expansion in the Cerrado are economically unsustainable and undermine the stability of the entire global supply. The world is facing finite agricultural frontiers and accelerating ecosystem damage. Supporting deforestation-free supply chains and investing in forest conservation could safeguard the productive capacity of existing suppliers and ensure long-term, stable soy supplies.

Sourcing from regions that suffered the most production losses shows supply chain vulnerability

1. Two importers dominate the international market for Brazilian soy:China currently buys around three-quarters of the country's soy exports, making it the country's biggest soy trade partner
2. The EU purchases around 7% of Brazil's soy exports., making it the second biggest import market.

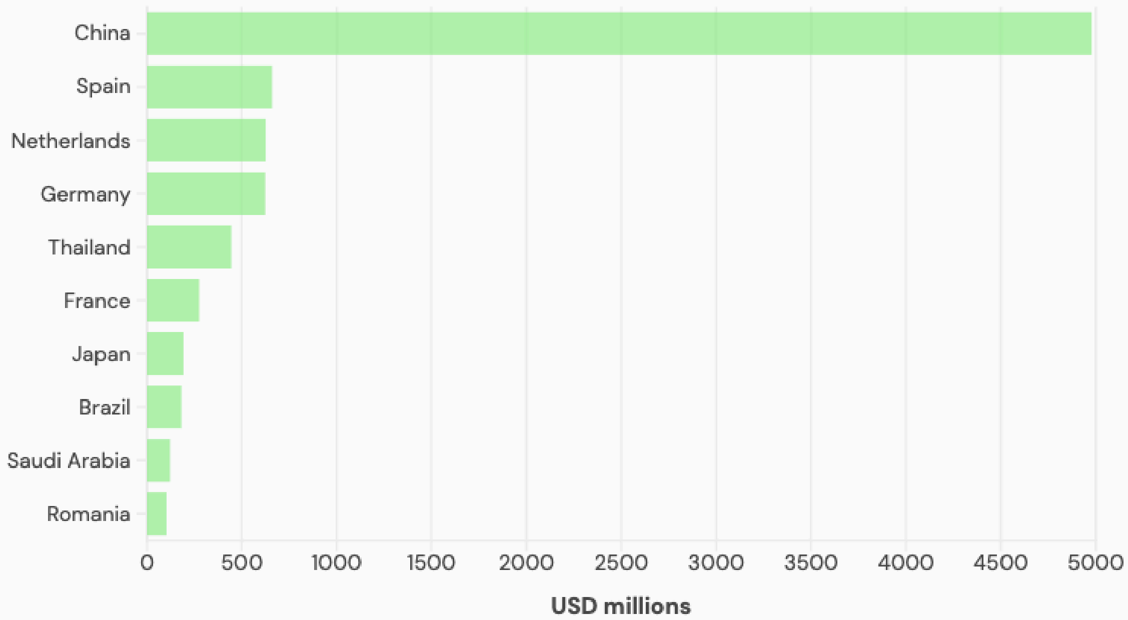
Because most of Brazil's recent soy expansion has been in the Cerrado, these buyers are highly exposed to clearing-linked risk, particularly for sourcing in the Cerrado's Matopiba region.

Sourcing from regions where productivity is being undermined by deforestation means greater uncertainty in future soy availability and upward pressure on costs. To compare the risks in each country's supply chain, we assessed which importing countries were most exposed to hidden productivity losses between 2013 and 2023. We identified the regions each country sources from and calculated the value of the soy that was never produced due to clearing-induced losses in each region (Figure 2).

Figure 2

Exposure of major soy-importing countries to deforestation-linked production losses

Bars show the USD of soy output that weren't realised because clearing reduced regional productivity, valued using the actual local prices (2013–2023).



Source: ZCA analysis of Trase Earth data • Dollar values show potential agricultural value preserved if clearing were avoided. Prices are observed FOB.

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China has, by far, the highest absolute exposure to clearing-linked production losses, partially because it is the largest importer, followed by Spain, the Netherlands, and Germany.

China sources from Cerrado municipalities where land clearing destroyed almost USD 5 billion worth of soy production capacity from 2013 to 2023, equivalent to around half of the total value lost over the period.[14] Without efforts to restore degraded land, this hidden productivity loss is permanent. This figure only reflects clearing during our study period; decades of prior deforestation mean total productivity losses are substantially larger.

[14] This represents foregone production in China's sourcing regions, not a direct cost to Chinese importers, but a measure of how much productive capacity has been lost in the areas where China sources its soy, and therefore the risk to China's supply chain. China may not be the only importer sourcing from each region.

Box 3: China's food supply chain security depends on Brazil's Cerrado conservation actions

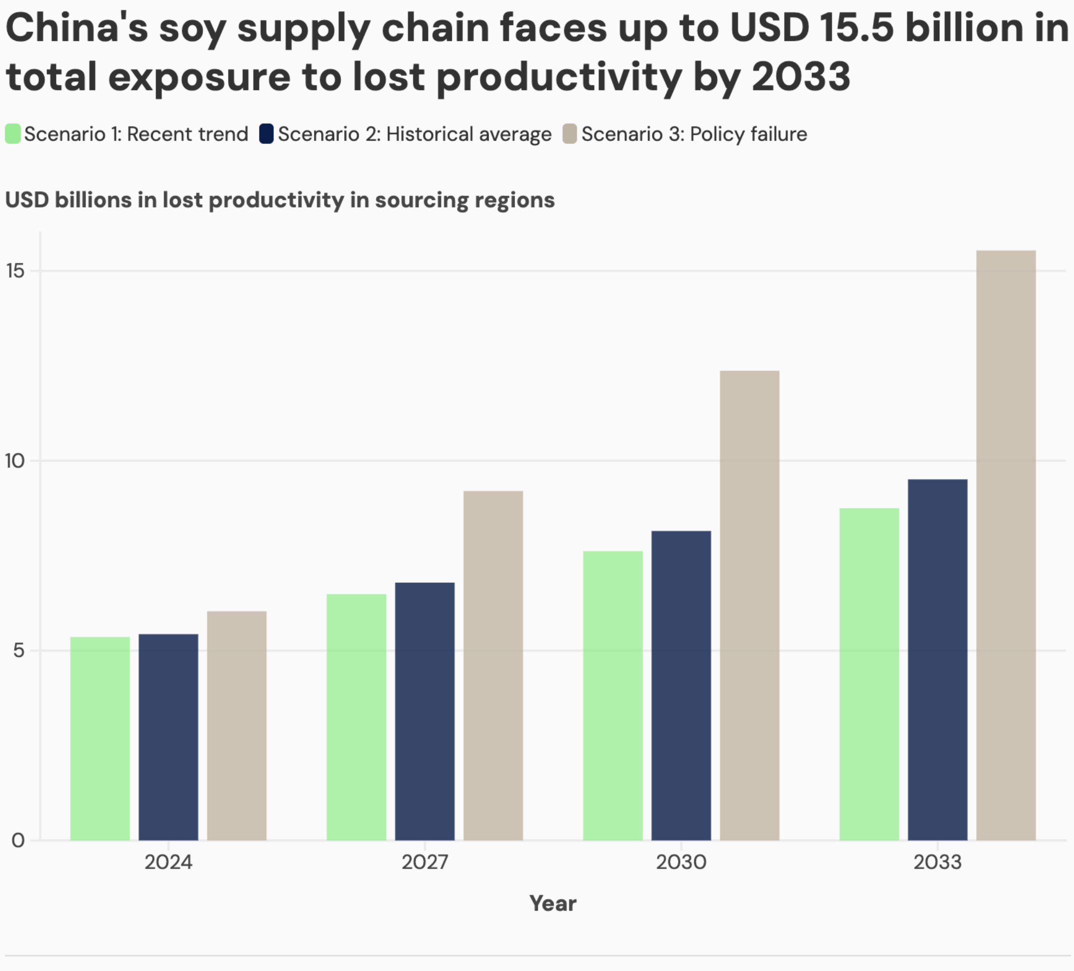
As the top importer of Brazilian soy, China's supply chain faces mounting risks from continued deforestation in its sourcing regions. China's supplies are geographically concentrated, amplifying risk - our analysis showed that 60% of China's import volume from the Cerrado[15] comes from just three states: Mato Grosso (29.7%), Goias (20.1%) and Bahia (10.1%).[16]

Brazil's deforestation protection policies, and how thoroughly they are enforced, will have a big impact on the future exposure of China's supply chains. To give an idea of the scale of this impact, we modelled three future scenarios for the municipalities China sources from with different deforestation rates, and projected how much production capacity could be destroyed by 2033 (Figure 3):

- **Recent trend:** If the average clearing rate from 2013 to 2022 continues (361.2 kilohectares per year), another USD 3.8 billion in productive capacity will be eliminated in China's sourcing regions by 2033. This would bring the total productivity loss in the regions since 2013 to USD 8.7 billion.
- **Historical average:** A return to the higher average clearing rates seen from 2008 to 2022 (435 kha/year) would mean additional productivity destruction reaches USD 4.5 billion, totalling USD 9.5 billion.
- **Policy failure:** If conservation policies are weak and deforestation accelerates to rates projected by a recent analysis, at approximately 2.3 times historical rates (1,019 kha/year),[17] China's sourcing regions could face an additional USD 10.6 billion in productivity destruction, for a total exposure of USD 15.5 billion by 2033.

Figure 3

[15] China sources Brazilian soy from 2,381 municipalities across 23 states nationwide, but our analysis focuses on 840 Cerrado municipalities.
[16] 24.7% of China's imports came from the Matopiba region.
[17] The paper estimates that the Cerrado loses 26.5 million hectares by 2050 under current Forest Code, which works out to 1,019 kha/year.



Source: ZCA analysis of of Trase data. Scenario 1: Recent trend assumes continuation of 2013 to 2022 deforestation rates of 361.2 kha/year; Scenario 2: Historical average assumes continuation of deforestation rates from 2008 to 2022 of 435 kha/year; and Scenario 3: Policy failure is based on accelerated clearing under policy failure of 1,019 kha/year (derived from Colman et al., 2024).

Changes to trade dynamics have amplified China's soy supply chain exposure

China's supply chain exposure has intensified with recent trade dynamics. US-China trade tensions drove Brazilian soy's share of Chinese imports up to 71% in 2024, while US exports to China fell to zero from May 2025, down from 21% in 2024.[18, 19] Simultaneously, the EU's new Deforestation Regulation (EUDR) may redirect deforestation-linked soy toward non-EU markets, such as China.

[18] Bloomberg Intelligence report: Global Agriculture, Trade War Threatens US Chain as Opportunities Head South (2025). Accessed 13 October 2025.
[19] China and the US are reported to have discussed expanding farm trade, including soy, in October 2025.

As EU buyers claim deforestation-free supplies, China risks inheriting a portfolio of suppliers from precisely the regions experiencing the highest productivity losses. These losses create supply chain fragility rather than immediate shortages. Degraded landscapes are less resilient to climate shocks, meaning droughts, floods or heatwaves that would be manageable in intact ecosystems can cause significant production disruptions. China's concentrated dependence on these degraded regions amplifies vulnerability.[20]

Brazil's Soy China initiative is an opportunity to secure supply

Brazil and China's new 'Soy China' initiative – a dedicated supply chain meeting Chinese sustainability standards – presents an opportunity to address productivity risks. The framework could allow China to demand deforestation-free sourcing, backed by economic self-interest. Our findings confirm that conservation and soy output are not only compatible but that reducing deforestation is essential for sustaining long-term productivity.[21]

Countries that source soy from high-clearing areas have the most to gain from investing in conservation

Countries sourcing soy from the Cerrado region can enhance their supply chain security by investing in conservation efforts – preventing the deforestation that puts their imports at risk – or by shifting their supply chains to forest-positive suppliers.

Examining which countries source the most soy from heavily-cleared areas provides an indication of which countries could benefit the most from investing in Cerrado conservation to enhance their supply chain sustainability.[22]

[20] Brazil can still meet China's volume demands in the near term. The risk is not immediate supply shortage, but rather systematic degradation of the productive base. As landscapes lose productivity, maintaining output requires either expanding clearing (worsening climate impacts) or accepting yield declines, meaning soy production in the region becomes increasingly vulnerable to disruption.
[21] Brazil's dependence on China as the single-largest buyer also places Brazil's export programme at risk of shifts in Chinese demand or policy, trade disputes or economic slowdown.
[22] In our calculations of the total value of lost production (above), countries that import the most will rank highly because they have a large import volume. Looking at which countries have sourced the most from highly-impacted regions results in a per-unit conservation benefit, showing which countries can most effectively work to protect their imports, regardless of volume.

For each major importer, we estimated the soy output lost between 2013 and 2023 in the municipalities it buys from, then divided this by the amount of soy the country imported. This gives a per-tonne exposure intensity: higher values mean more sourcing from heavily-cleared areas and greater vulnerability to continued productivity losses.[23]

Germany ranks highest. For every tonne of soy Germany imports, its sourcing regions lost USD 43 of productive capacity between 2013 and 2023 due to deforestation. Germany's soy purchases are concentrated in municipalities that are actively clearing the Cerrado, which means each tonne imported is linked to more local production loss than other buyers.[24]

However, countries that source heavily from regions affected by clearing are well-positioned to lead supply chain sustainability efforts. Every million tonnes that Germany shifts toward forest-positive suppliers would preserve USD 43 million in regional productivity (Figure 4). Germany is followed by:

- Saudi Arabia (preserving USD 28/tonne)
- Spain and Romania (each USD 25/tonne)
- Japan (USD 23/tonne).

China has the largest total exposure (Figure 2) because of its high import volumes but a lower intensity (USD 11/tonne).[25]

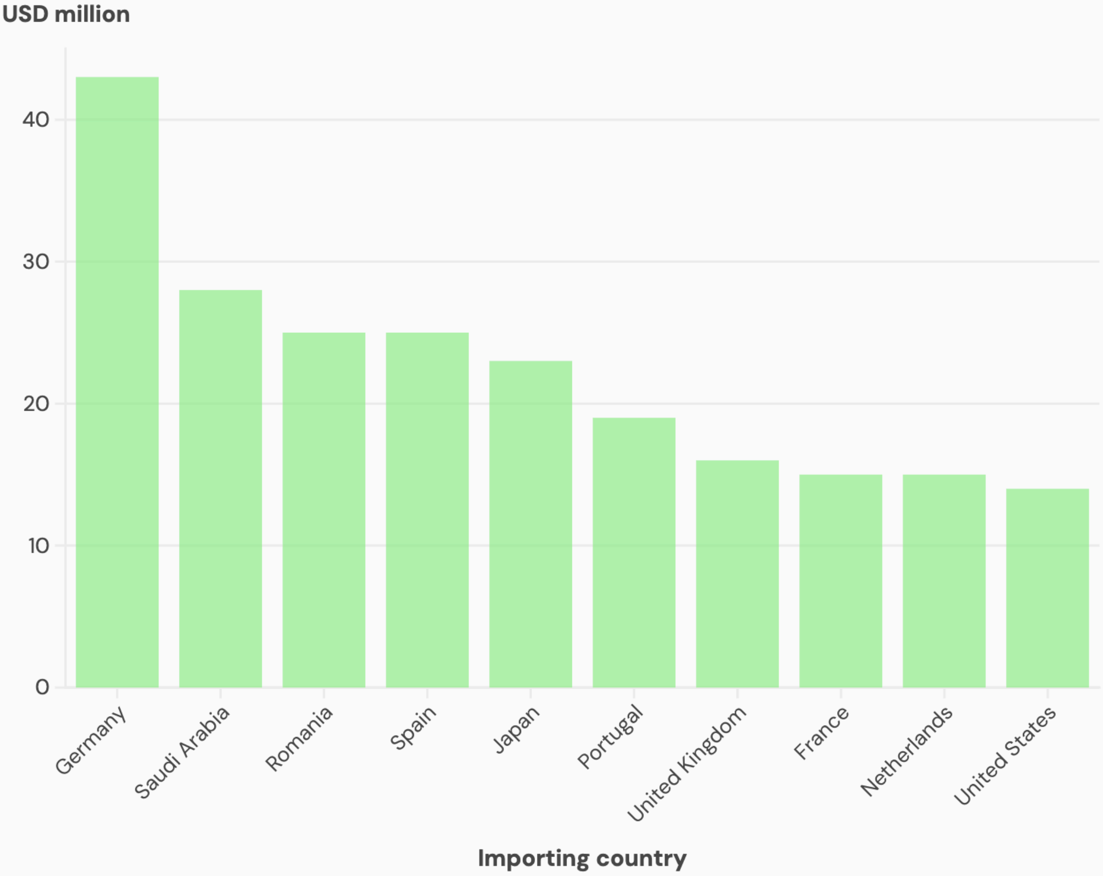
However, sourcing patterns are highly overlapped: Germany sources from municipalities where 98.7% of productivity benefits from conservation investment would be shared with other importers, primarily China. This creates a collective action challenge where conservation benefits are shared but costs may fall on individual investors, making coordinated funding more viable than unilateral action. Addressing deforestation-driven productivity losses therefore requires coordinated action, such as multilateral conservation mechanisms, supply chain consortia such as the Soy Moratorium or policy mechanisms such as the EU's Deforestation Regulation (EUDR).

[23] We quantified municipality-level soy productivity losses from deforestation using fixed-effects panel regression models covering 840 Cerrado municipalities over 2013-2023. We converted losses to monetary values using municipality-specific FOB prices (USD/tonne) and matched these to country-level import flows using Trase supply chain data. To calculate country exposure, we allocated municipality losses to importing countries proportionally based on trade volumes. The exposure intensity was calculated as each country's cumulative attributed losses divided by its total import volume. These values represent foregone production in source regions due to clearing, not direct costs to importers.
[24] 52% of Germany's imports came from the Matopiba region – the active agricultural frontier.
[25] While total exposure (USD millions) shows scale, USD/t shows how clearing-exposed each imported tonne is.

Figure 4

Importers can protect productivity in their sourcing regions by shifting to forest-positive supply

Productivity value preserved per million soy tonnes shifted to forest-positive suppliers, for the top ten importers most exposed to deforestation impacts



Source: ZCA analysis of Trase data

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Box 4: For the EU, the economics favour Cerrado preservation as deforestation regulations ramp up

Our analysis reveals that EU importers have already absorbed at least USD 2.47 billion in hidden productivity losses from Cerrado deforestation over our study period. This cost will only grow without intervention to drastically reduce deforestation, our data, together with other studies, show.

Historical assessments estimate that the EU-soybean trade with Brazil and Argentina caused a cumulative loss of natural capital or ecosystem services of USD 1.7 trillion between 1961 and 2008, underscoring the long-term economic toll of land conversion.

Trade dynamics amplify this: EU–US tariffs announced this year have made US soy a costlier and less reliable option for European buyers. The European Commission imposed an additional 25% duty on US soybeans, which will take effect on 1 December 2025, as part of its retaliatory tariff package. This will raise import costs for EU buyers and reduce the competitiveness of US supply in the EU market.

At the same time, China dominates global soy demand, accounting for 60% of global imports, which intensifies competition for remaining export volumes and limits Europe's leverage in securing a stable, low-risk supply.

EU exposure to deforestation regulations

The EU Deforestation Regulation (EUDR) prohibits EU countries from importing commodities from land that has been deforested since 31 December 2020. It was officially signed into law in June 2023 and is only anticipated to be fully implemented by December 2026.

Examining where EU countries sourced their soy from in 2022 and calculating their per-tonne exposure intensity gives an indication of how hard it will be for member states to comply with the EUDR. (2022 is the most recent trade data in our dataset reflecting 2017-2021 deforestation – just four years before and one year after the cutoff for deforestation-free imports.) .

Romania shows the highest exposure (USD 72/tonne), suggesting its supply chains were particularly linked to new clearing immediately before the EUDR cutoff.

France has the highest absolute exposure of EU countries (USD 45.8 million), while large-volume importers like Spain and the Netherlands show lower intensities (USD 9/tonne and USD 7/tonne, respectively), indicating more diversified sourcing away from recently-cleared municipalities.

These patterns suggest that EU countries face differential EUDR compliance challenges. If those with high 2017-2021 exposure intensities have maintained similar sourcing patterns post-2020, they will require more substantial supply chain restructuring to meet EUDR requirements.[26]

New analysis identifies narrow window in which conservation can be most effective - before critical thresholds are permanently crossed

- Our data analysis shows that the relationship between deforestation and climate impacts evolves: the first hectares of clearing cause the most severe climate disruption.
- The data also indicates that there is a turning point, after which additional clearing in an area causes progressively less additional damage.[27]
- This evidence suggests that a conservation policy for the Cerrado is urgently needed if the soy industry is to be sustained or grown.

This threshold has implications for conservation strategy. Below the turning point, each hectare of vegetation loss creates large increases in local dryness, making conservation efforts highly effective at preventing climate damage.

Nearly all municipalities that experienced clearing during our study period remain below this critical threshold,[28] meaning policies prioritising Cerrado protection could effectively

[26] These results indicate supply chain risk profiles based on historical patterns rather than providing definitive EUDR compliance assessments. If EU countries shifted their supply chains between 2017 and post-2020, their EUDR exposure may differ from these estimates.
[27] We estimated linear and quadratic coefficients for deforestation, which revealed an inflection point in the relationship between clearing and aridity. Below this inflection point, additional deforestation drives increasingly severe drying effects; beyond it, the marginal impact on SPEI decelerates, suggesting a plateau in sensitivity once forests are already heavily reduced.
[28] Of the municipalities that experienced deforestation during our study period, only two exceeded the inflection point and entered the "plateau-response zone". In these few municipalities, efforts might shift toward restoration strategies, such as reforestation or agroforestry, to rebuild moisture-regulating capacity.

prevent further damage. Once municipalities cross the turning point, additional conservation delivers much smaller climate benefits, as most of the damage has already occurred.

Brazil faces a present but shrinking policy window: its advantage of being below the threshold will be permanently lost as clearing intensifies and interventions give diminishing returns.

This copy was reformatted in February 2026.