August 2023

Benchmarking commodity production regions for risks of deforestation and conversion

Introduction

This document builds on the methods developed by Trase and Proforest, with input from the Accountability Framework initiative (AFi) secretariat and in partnership with the Consumer Goods Forum's Forest Positive Coalition (FPC), to classify the deforestation and ecosystem conversion risk of sourcing regions for beef at the country level and soy at the subnational level in Brazil. It describes the datasets, methodological choices for risk benchmarking and the methods developed for benchmarking countries for beef globally and municipalities for soy in Brazil. Although this document focuses on these two applications, the general approach is designed to be applicable to any agricultural commodity.

Datasets

There are significant gaps in the availability of spatially explicit global crop and pasture maps (Pendrill et al 2022). Many datasets with global coverage rely on simple land-balance models where deforestation linked to a specific commodity is estimated based on the total expansion of that commodity in a specific area, linked to total deforestation in that area, without information on exactly how much forest was replaced by the expanding commodity. Similarly, many datasets on commodity deforestation are limited to tropical deforestation and do not cover the conversion of other natural ecosystems. To overcome these challenges, we used a combination of different datasets. As a result, for the national scale method, we used mostly

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non-spatially explicit data with global coverage. For the subnational scale method, we used high-resolution spatial data on soy conversion derived from satellite imagery. The methods are responsive and can be easily adjusted to integrate new data as it emerges.

National risk categorisation

We only used datasets with global coverage to enable risk assessment of all countries producing cattle which are potentially exposed to recent cattle-driven deforestation[1]. These datasets are classified into two categories: (1) non-spatially explicit deforestation attribution to crops and pasture, which includes statistical/census data by country and spatially explicit specific data on land-use cover; and (2) spatially explicit deforestation attribution to crop distribution.

1. Non-spatially explicit datasets:

- *Pendrill et al. (2022)*: a global, openly available, peer-reviewed dataset that provides global estimates of tropical and subtropical deforestation associated with the production of a wide range of agricultural commodities including soy, palm oil, cattle and timber. The dataset uses observed forest loss from GLAD satellite data attributed to agricultural and timber commodities using a simple land-balance model implemented at national scale (subnational in the case of Brazil and Indonesia). In this land-balance model, forest loss is attributed across expanding cropland, pasture and managed forest plantations based on their area increase using FAO data, but capped at total estimated forest loss in the focal region. Forest loss attributed to cropland expansion is further attributed to individual crops or crop groups in proportion to their relative expansion in the harvested area. We considered the average annual cattle deforestation by country that had taken place in the last five years of available data (2014–2018).

- *FAOSTAT production data*: global agricultural production data, including crop and livestock production, fishery and forestry products, and primary and processed food items. The database covers more than 245 countries and territories, and contains data on production quantities, area harvested, yield and trade statistics. We used the total quantity of cattle production (tonnes) by country for all countries with records of production in the year of interest. We considered the average of the annual commodity production by country over a five-year period (2014–2018). Cattle production includes

[1] Commodity deforestation and ecosystem conversion is defined as the area used to produce a commodity that has been recently deforested or converted.

all products derived from cattle[2] that is aligned with the list of products used by Pendrill et al. (2022).

- *Country boundaries (generalised)*: represents generalised boundaries for the countries of the world as of August 2022. Developed by Esri and sourced from the National Geographic Society, the US Central Intelligence Agency (The World Factbook) and Garmin International.

2. Spatially explicit dataset:

- *Global Forest Watch agriculture-linked deforestation*: Provides deforestation information linked to specific commodities; namely, cattle, oil palm, soy, cocoa, rubber, coffee and wood fibre. By overlaying recent maps of commodity production areas with maps of historical tree-cover loss, GFW (2015) data shows where previously forested lands have been replaced by agriculture according to specific land uses. The data covers multiple years between 2001–2015 at subnational administrative scale. We considered the average annual cattle deforestation by country that had taken place in the last five years of available data (2011–2015). This dataset was used to address gaps in the Pendrill et al. (2022) dataset, which only covers tropical and subtropical regions.

- *OECD land-cover change*: provides information on changes in land cover and land use from 1990 to 2019. It covers over 200 countries and territories, and includes data on natural ecosystems change, cropland expansion, urbanisation and other land-cover changes. The dataset is based on satellite imagery and other remote sensing data, and is intended to support analysis of the environmental, economic and social impacts of land-use changes. We used the OECD land-cover change dataset to estimate the average annual loss of natural ecosystems between 2014–2018 due to the expansion of croplands.

Subnational risk categorisation

The subnational risk categorisation focused on Brazil. Data on the conversion of natural ecosystems to soy croplands is provided at a spatial resolution of 30 metres. We calculated the area of conversion of natural environments to soy from land use and land-cover data by MapBiomas (2020), PRODES (2020) and Song et al (2021). We considered the direct conversion of native vegetation to soy using the following data sources:

[2] From FAO production data, we selected all products that are derived from cattle (mass of production of derived products from slaughter), which include the following codes: 867 (meat, cattle); 868 (offal, edible, cattle); 869 (fat, cattle); 919 (hides, cattle, fresh); 947 (meat, buffalo); 948 (offal, edible, buffalo); 949 (fat, buffalo); and 957 (hides, buffalo, fresh).

- *MapBiomas*: MapBiomas is a Brazilian initiative that produces a comprehensive annual land use and land-cover map of Brazil using remote sensing and geoprocessing of landsat images stored in Google Earth Engine. The project is updated annually, and the latest version covers the period from 1985 to 2021. We used it to map soy-specific conversion from natural ecosystems. We considered the soy conversion by Brazilian municipalities that had taken place in the last five years of available data. We considered all land converted between 2016–2020 as direct soy conversion for soy crops cultivated in 2021 (Song et al., 2021).

- *PRODES*: a remote-sensing monitoring system developed by Brazil's National Institute for Space Research (INPE, 2020) to track conversion of natural ecosystems in the Brazilian Amazon and Cerrado biomes. The system provides annual estimates of conversion rates and produces high-resolution land-change maps that show the location and extent of converted areas. We used PRODES conversion data only in the Amazon and Cerrado biomes, while the conversion in the remaining biomes was estimated using MapBiomas. We considered all land converted between 2016–2020 for soy crops cultivated in 2021 (Song et al., 2021) as direct soy conversion[3].

- Song et al (2021): The authors mapped the area of soy production and its associated deforestation using a combination of satellite imagery, land-cover data and machine learning algorithms. They used high-resolution satellite imagery from the European Space Agency's Sentinel-2 mission to identify areas of soy cultivation. They also used TerraClass data, which provides detailed land-cover information for Brazil. They trained machine learning models to classify the satellite imagery and identify soybean fields in Brazil. We used the soy crop area in 2021 from Song et al (2021) overlaid with areas of deforestation according to MapBiomas and PRODES.

Methods

Methodological choices

The development of the methodologies for national and subnational risk categorisation included three key choices that were determined by the purpose of risk benchmarking (as shown in Figure 1): *scale of analysis*, *risk perspective* and *risk assessment method*.

[3] While data from Mapbiomas was used to perform this step for the FPC, data presented in this document replaced Mapbiomas data on deforestation and ecosystem conversion by Prodes data for the Amazon and Cerrado biomes in order to align with Trase data on soy conversion that uses official data where possible.

1. The **scale of analysis** refers to both the geographical scope and unit of analysis used in the risk assessment process. For instance, in a national risk assessment for cattle deforestation, the geographical scope is the entire world, and countries are the units of analysis. In the case of sub-national risk assessments, political administrative regions are most likely to be the units of analysis.

2. The **risk perspective** comprises different viewpoints for categorising risks: (1) 'ecosystem' encompasses the scope of conversion type; for example, deforestation or conversion of other types of natural ecosystems; (2) 'commodity' refers to whether the deforestation and conversion is associated with a specific commodity, or for all agricultural use, or encompasses all deforestation and conversion; and (3) 'supply chain' refers to whether the commodity conversion is associated with specific buyers in the supply chain, such as countries or traders, or is a jurisdictional perspective. In many cases the chosen perspective will be influenced by data availability. There are currently significant gaps in the availability of global data on commodity crop and pasture maps and the conversion of natural ecosystems with available data typically limited to tropical regions and deforestation.

3. The **method of risk assessment** describes the approach for categorising production regions into different levels of risk and includes both absolute and relative risk approaches. The absolute approach applies specific thresholds of conversion that are informed by the overall area of conversion. For example, in order to identify countries or regions as at risk of conversion, a threshold of 5,000 hectares of conversion could be applied. Any country or subnational region that exceeds this threshold would be categorised as at risk. In contrast, the relative approach can be used, for example, to categorise regions according to their proportional contribution relative to the total conversion in the geographical area of interest. For example, municipalities in Brazil could be benchmarked by their relative contribution to overall soy conversion in Brazil as a whole and ranked from highest to lowest in terms of their relative contribution. Under a threshold of 99% for categorising municipalities as at risk, municipalities ranked from highest to lowest that cumulatively account for 99% of total soy conversion would be categorised as at risk. The relative risk approach ensures that the risk level is consistently benchmarked against the total level of a commodity's deforestation impact. In contrast, the absolute method makes it difficult to compare countries and regions of different sizes and between commodities on a like-for-like basis as the size of regions and scale of deforestation across and within countries and commodities varies so much.

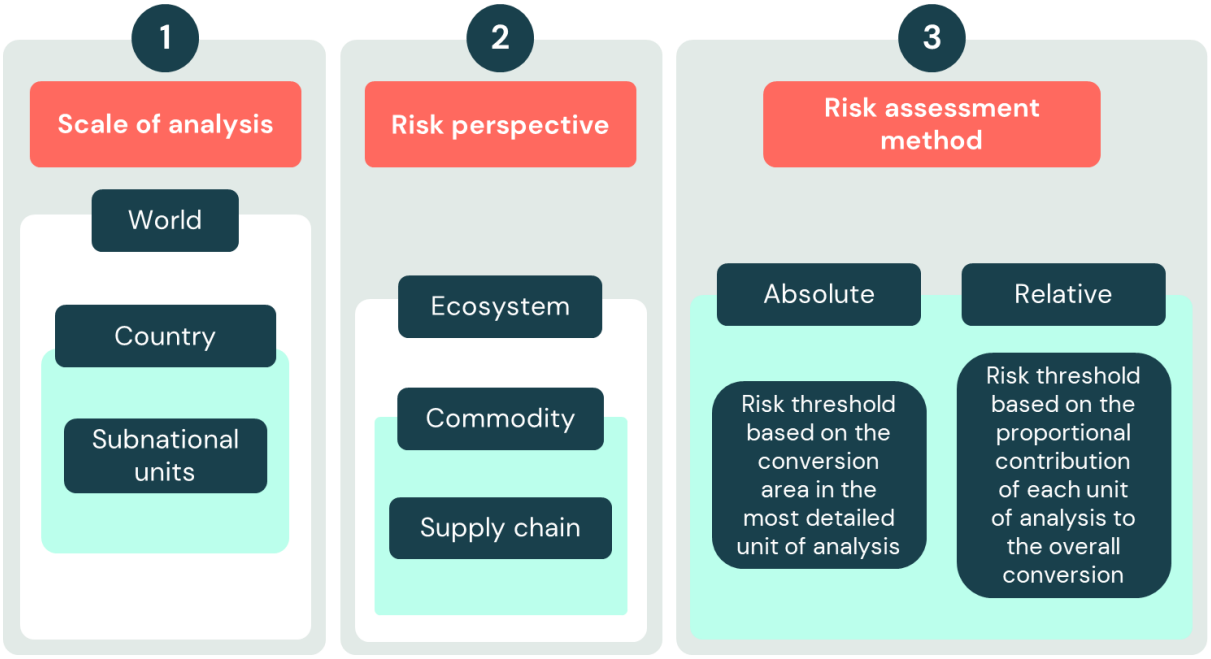


Figure 1: Key concepts and methodological choices for national and subnational risk categorisation of commodities' origins

National risk benchmarking for cattle deforestation

The methodology scope was global with a focus on benchmarking countries (the scale of analysis). While the scope was both cattle deforestation and conversion, due to data gaps on cattle-driven conversion, the methodology focuses on cattle deforestation and uses safeguards to address the risk of direct or indirect conversion of natural ecosystems associated with cattle. A relative risk approach was used to benchmark countries based on their proportional contribution to global cattle deforestation.

Countries were classified into two categories – negligible risk and at risk – using the steps set out in Figure 3.

- *Negligible risk countries*: countries in which there is no evidence of commodity deforestation from Pendrill et al. (2022) or Global Forest Watch (2015), as well as no relevant ecosystem conversion (OECD, 2019)[4] in the years 2016–2019. Countries are considered to be at negligible risk if they meet the following criteria: (1) the country is among a set of commodity producing countries that cumulatively contribute to less

[4] Ecosystem conversion comprises the conversion of all natural environments (forests, shrubs, grasslands, and wetlands) to agriculture. Here we differentiate the terms 'deforestation' and 'conversion'. Deforestation refers only to the expansion of commodities into forests, while conversion refers to the conversion of all natural environments.

than the selected cattle deforestation threshold; (2) the country has a low deforestation intensity (commodity deforestation divided by commodity production in the same period); and (3) the country is either not a major global commodity producer or is in the list of countries that contribute to less than 25% of the global ecosystem conversion to croplands of any kind according to OECD (2019).

- *At-risk countries*: countries in this category have evidence of direct deforestation caused by commodity production or present a relevant area of conversion from natural ecosystems to croplands in regions of commodity production. Regardless of the amount of conversion in a given country, further traceability and monitoring is required to determine the deforestation-free status of any commodities sourced from the country or from regions within the country.

Detailed description of the risk categorisation steps:

Step 1: Benchmarking and ranking countries' relative cattle deforestation risk

a. Bringing the data together

- **Is there recent deforestation data available for the period of interest?** As discussed above, the data provided by Pendrill et al. (2022) is focused on tropical and subtropical regions. Therefore, we supplemented this data by using commodity deforestation data from GFW (2015). Countries without commodity deforestation information in GFW (2015) and Pendrill et al. (2022) are classified as having no data. For countries with available information, the risk categorisation was conducted by using both the GFW (2015) and Pendrill et al. (2022) datasets. For the Pendrill et al. (2022) dataset, we used 'deforestation attribution' information for cattle meat products considering 'deforestation risk amortised (hectares)'.

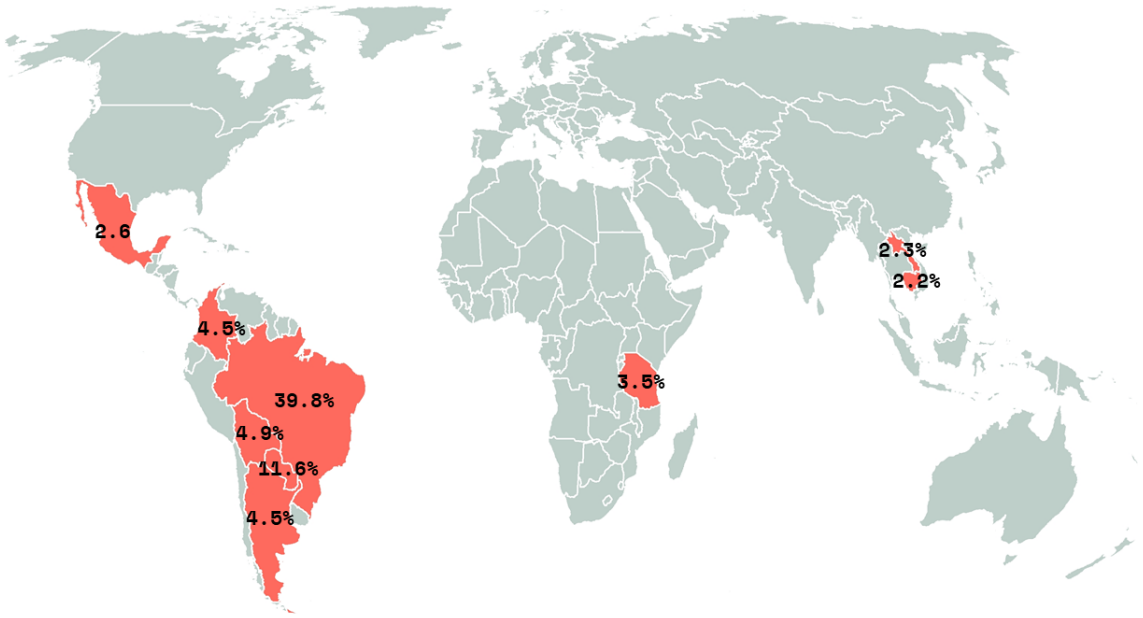
b. Benchmarking and ranking countries' contributions to global cattle deforestation

This step involves assessing the relative contribution of each country to global cattle deforestation, and ranking them accordingly. We first estimated the cattle deforestation of each country in relation to the total global cattle deforestation. Then we ranked the countries based on their relative contribution to global overall cattle deforestation as shown in Figure 2[5].

[5] Figure 2 shows the use of the cumulative relative contribution approach of countries to global cattle deforestation based on GFW (2015) cattle deforestation area and is intended as an example. The risk categorisation methodology discussed in this document is not restricted to cattle deforestation and uses a recommended threshold of 99% rather than 75%. As shown in Figure 3, other variables are taken into account to provide a comprehensive risk categorisation to ensure that countries categorised as negligible risk are free of deforestation and conversion.

Due to data gaps we created two rankings, one using the Pendrill at al. (2022) dataset and the other using the GFW dataset. Both rankings were used to apply the benchmark. Where countries were present in both datasets and received different classifications of risk, the most conservative selection was chosen. Thus, if the risk classification was negligible for Pendrill but at risk for GFW, the at risk classification was applied.

- **Is the country a significant contributor to global deforestation for the given commodity?** A country has significant levels of deforestation if it is on the list of ranked countries (starting from highest to lowest) that cumulatively account for a selected threshold of global cattle deforestation. The recommended threshold for the FPC beef members is 99%. These countries are considered at risk due to cattle deforestation. As noted above, countries are identified as at risk if they are in the cumulative 99% of contributions to global cattle deforestation for either the ranking using the Pendrill at al. (2022) or GFW (2015) datasets.



Country	Deforestation area (ha)	Relative deforestation	Cumulative deforestation
Brazil	1,153,258	39.8%	39%
Paraguay	336,144	11.6%	51%
Bolivia	142,993	4.9%	56%
Argentina	131,393	4.5%	60%
Colombia	127,691	4.4%	65%
Tanzania	101,308	3.5%	68%
Mexico	741,77	2.6%	71%
Laos	65,482	2.3%	73%
Cambodia	62,965	2.2%	75%

SUM

Countries accounting for 75% of the global deforestation

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Figure 2: Ranking of countries based on the cumulative relative contribution approach for cattle deforestation, based on the average cattle deforestation (2011–2015) by GFW (2015). This example shows the top countries representing 75% of the global cattle deforestation. For this example, we used only the GFW dataset.

Step 2: Integrating safeguards into the risk classification

The safeguards consist of two additional steps: one based on cattle deforestation intensity within countries, and the other based on the contribution of relevant cattle-producing countries to global ecosystem conversion resulting from agricultural expansion. These safeguards apply to countries that have been identified as negligible risk in step 1.

a. Safeguards on high-intensity cattle deforestation

- **Does the country have high levels of deforestation relative to its commodity production (high-intensity deforestation)?** Cattle deforestation intensity is calculated by dividing the cattle deforestation area (hectares) by the total volume (tonnes) of cattle production in the country. The resulting ratio is expressed as hectares of commodity deforestation per tonnes of commodity production. Countries with low cattle production may have disproportionately high rates of cattle deforestation and should be categorised as being at risk, even if they are not a significant contributor to global commodity deforestation. Countries in the top quartile (25%) of the highest cattle deforestation intensity are categorised as at risk due to high deforestation intensity. Again, this step is done separately using both the Pendrill (2022) and GFW (2015) datasets. If a country is in the top quartile in either dataset, it is categorised as at risk.

b. Safeguards on ecosystem conversion

Thus far, we have only considered cattle deforestation data. However, major producing countries that do not have significant levels of cattle deforestation or high cattle deforestation intensity may still be at risk due to direct or indirect conversion for cattle. We therefore also consider the following safeguards for conversion:

- **Is the country a major producer of the commodity?** Countries that are above the threshold of 75% when countries' proportional percentage contribution to global cattle production is cumulatively ranked from highest to lowest) are classified as negligible risk (the set of countries contributing to 25% of the global production), regardless of the amount of ecosystem conversion for agricultural use in that country.

- **Does the country convert globally significant levels of natural ecosystems to agriculture?** Major producing countries (countries that cumulatively contribute to 75% of global production when ranked from highest to lowest) that have high ecosystem conversion rates for agricultural use are considered to be at risk. This is defined as countries that cumulatively account for 75% of the global ecosystem conversion area for agricultural use when ranked from highest to lowest. Otherwise, they remain classified as negligible risk.

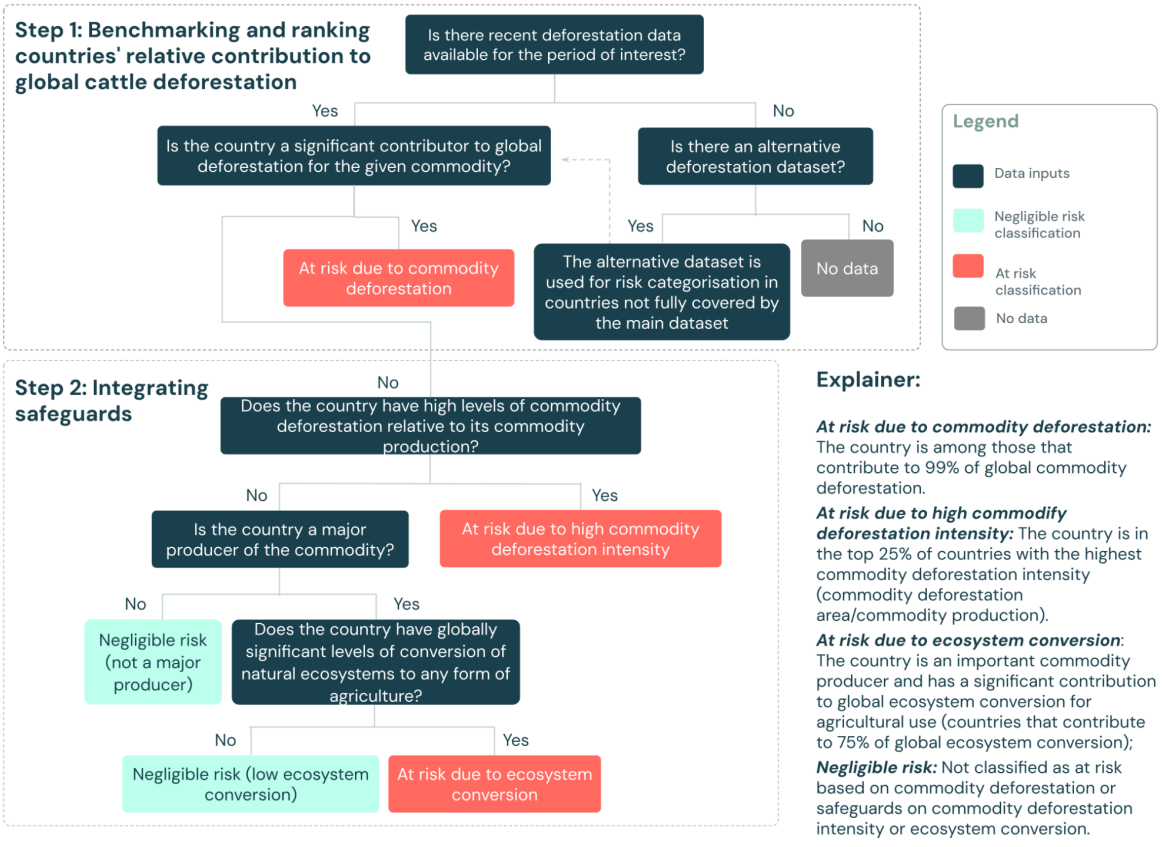

Figure 3: Method and decision tree used for classifying countries cattle deforestation and conversion risk as negligible risk or at risk

Subnational risk categorisation for soy conversion in Brazil

As shown in Figure 4, the risk categorisation can be applied at both national and subnational scales. The use of subnational risk categorisation is recommended for countries categorised as high risk and/or with large internal variations in conversion rates between subnational regions. For example, in the case of Brazil which accounts for 39.8% of global cattle

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deforestation risk according to GFW (2015), MapBiomas (2022) data at the subnational scale shows that this is centred in the Amazon and Cerrado biomes.

While the national risk categorisation only requires country-level data, subnational categorisation requires more detailed, high-resolution data that can be used to assess risks at a more granular scale. Subnational units of analysis could include political administrative regions, but could go down to the level of villages, concessions or farms depending on information availability.

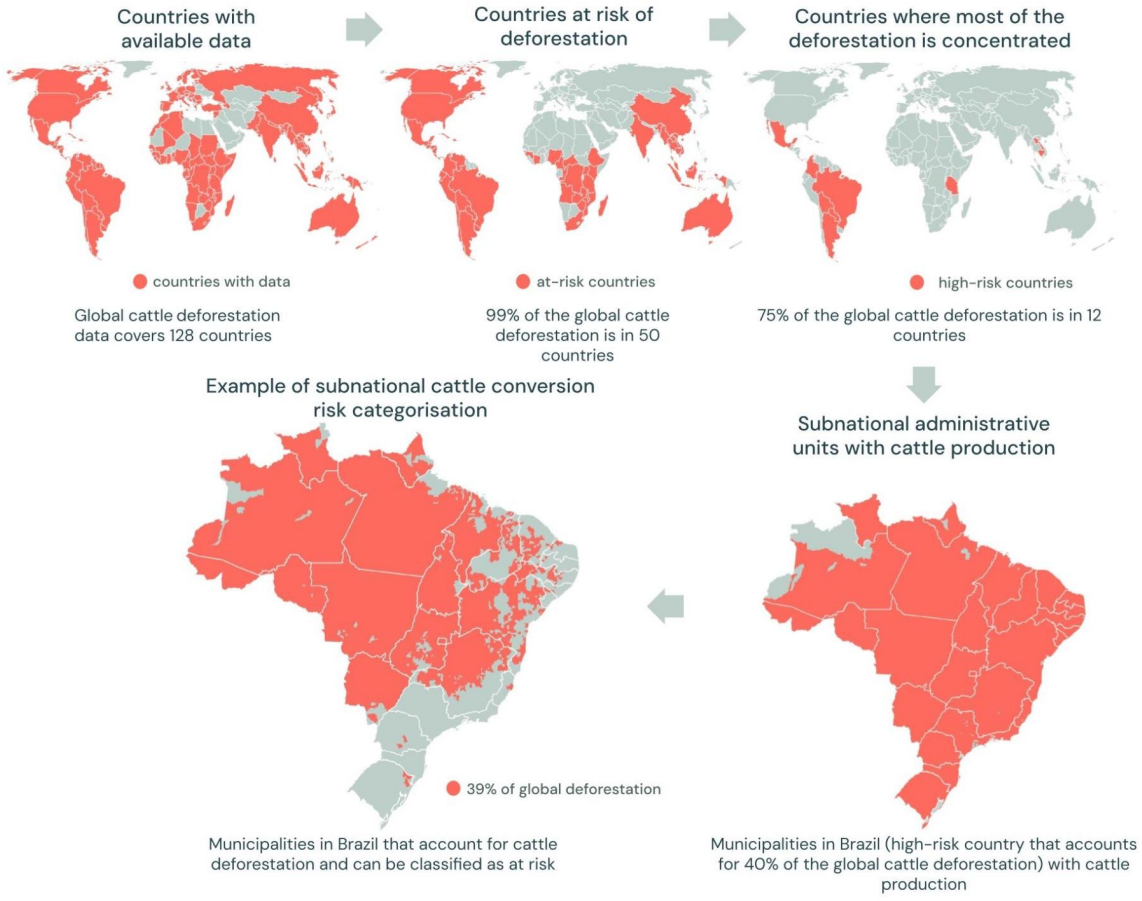

Figure 4: Example of risk categorisation from global to subnational scale. We considered the average cattle deforestation (2011–2015) according to GFW (2015) for the global risk categorisation, and the average pasture conversion (2016–2020) in Brazil according to MapBiomas (2020) for the subnational risk categorisation.

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The methodology scope was Brazil with a focus on benchmarking municipalities (the scale of analysis) and direct soy conversion. A relative risk approach was used to benchmark municipalities based on their proportional contribution to Brazil's total soy conversion.

Municipalities were classified into two categories – negligible risk and at risk – using the steps set out below.

Step 1: Benchmarking and ranking municipalities' relative soy conversion risk

a. Bringing the data together[6]

We estimated soy commodity conversion at the municipality scale for all soy-producing municipalities, employing two key principles: the lag period and the allocation period (Trase, 2022).

- The lag period refers to the minimum time required between a deforestation event and the first crop harvest. Lag periods vary depending on the specific commodity, considering the time needed for initial harvest and crop establishment. In the case of soy, there is a minimum one-year lag period between the deforestation event and the first soy harvest. This is because newly deforested land requires physical preparation before soy can be planted and subsequently harvested.

- The allocation period refers to the timeframe during which the production of a commodity can be confidently associated with a prior conversion event. This is determined by the length of time it typically takes to secure and prepare land for production (not only physical preparation, but legal permissions, credit etc). This period represents the window during which the commodity can be directly linked to and held more accountable for conversion. In the case of soy, a conversion episode would be associated with a soy crop occupying the same land if it occurred within the previous five years before the soy was planted.

By combining these two principles, we estimated the direct conversion associated with soy harvested in 2021 by analysing episodes of conversion occurring between 2016 and 2020. The soy conversion data was aggregated for each municipality and Brazil as a whole.

[6] While data from Mapbiomas was used to perform this step for the FPC, data presented in this document replaced Mapbiomas data on deforestation and ecosystem conversion by Prodes data for the Amazon and Cerrado biomes in order to align with Trase data on soy conversion that uses official data where possible.

b. Benchmarking and ranking subnational administrative units to national soy conversion

Risk benchmarking at subnational scale follows the same methodology as the global-scale risk assessment, as shown in Figure 2. The key difference is that the units of analysis are subnational administrative units, specifically municipalities instead of countries. It is important to note that, unlike the global risk assessment, safeguards were not implemented at the subnational scale due to the higher quality of the data and its comprehensive coverage of the conversion of all vegetation formations related to the target commodity.

c. Sensitivity analysis to select the risk threshold for categorising negligible risk regions

To inform the selection of the risk threshold for negligible risk municipalities we conducted a sensitivity analysis. The sensitivity analysis involved a series of quantitative analyses aimed at evaluating the impact of different risk thresholds on subnational regions of risk. To select the appropriate risk threshold, we focused on two specific aspects: (1) the proportional increase in the number of isolated soy-driven conversion events; and (2) the proportional increase in the number of municipalities with isolated soy conversion events across different risk thresholds ranging from 1% to 10% of the total national soy conversion.

An isolated conversion event is defined as a single commodity conversion event occurring within the minimum unit of analysis considered for the subnational risk categorisation, such as the municipality in this study.

To estimate the occurrence of isolated conversion events, polygons of natural vegetation conversion to soy were selected using a minimum size of 50 ha, which is the average national size of a single soy conversion event in Brazil (2016–2020). The total number of individual soy conversion events in Brazil was then calculated and repeated for each risk threshold from 1% to 10% in increments of 1%. We then calculated the proportional increase (Figure 5) in both the number of isolated soy conversion events and the number of municipalities with those events. For example, the proportional increase in isolated soy conversion events when increasing the threshold from 1% to 2% is 85% (Figure 5).

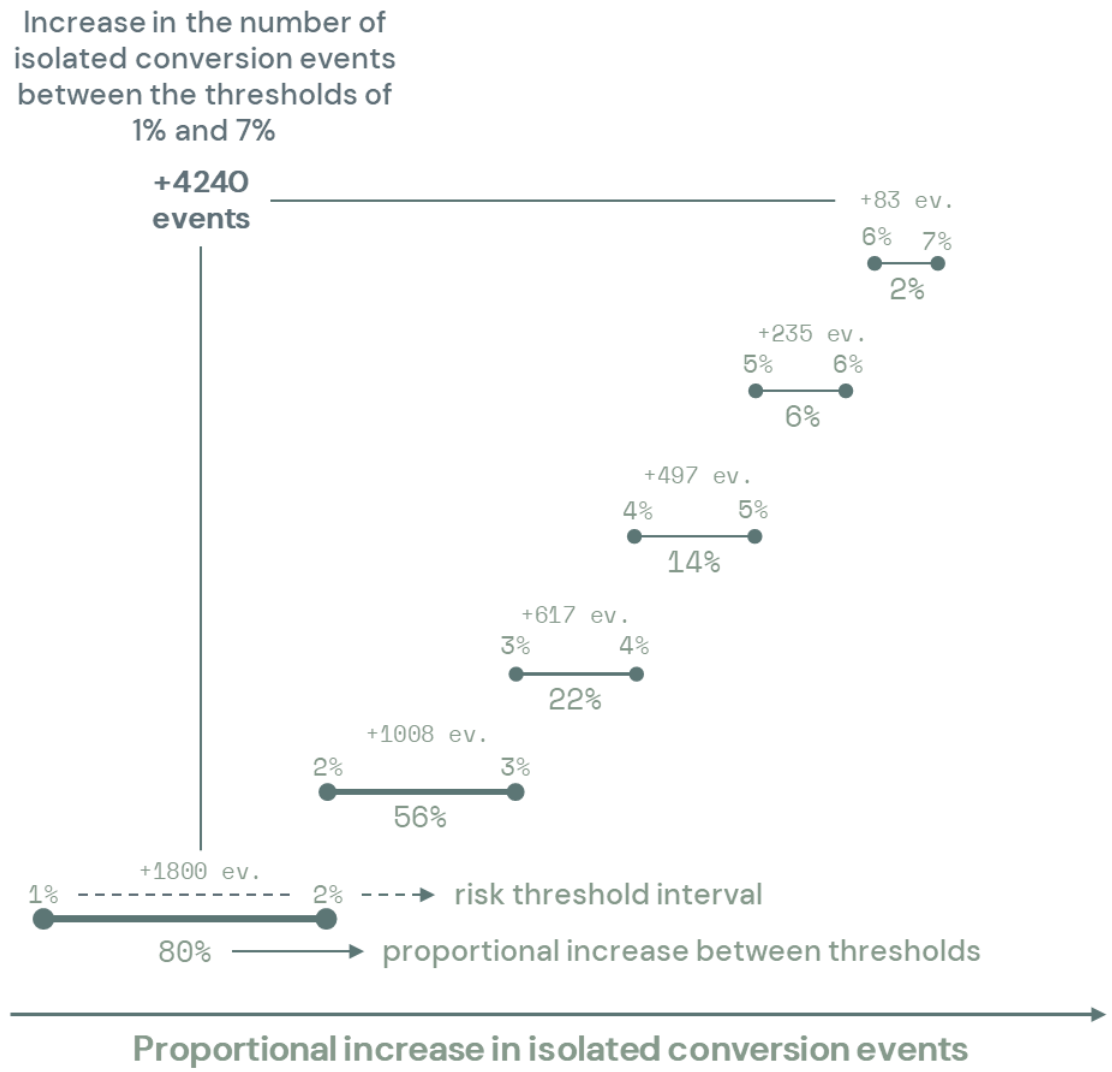

Figure 5: Example of proportional increase (percent change between thresholds) of isolated soy conversion events for different threshold intervals.

d. Final subnational benchmarking of soy conversion

The subnational risk benchmark was implemented following the results from the sensitivity analysis and the selection of an appropriate threshold. Subnational administrative units in all soy-producing regions of Brazil were subsequently classified as either negligible risk or at risk based on the selected threshold (as well as no soy production). Based on the sensitivity analysis results in this case, the recommendation was for a 1% threshold for negligible risk.

About the method

The term 'risk': This method uses past deforestation and conversion related to commodity production to assess the risk associated with a given commodity and country. The result indicates the recent deforestation and conversion footprint of commodities produced in a particular country or subnational region and is not a forward-looking projection. This is used to classify producing regions by risk of commodity deforestation.

At-risk countries: Countries or subnational regions that are potentially exposed to commodity deforestation and conversion can be identified using this method. The list of at-risk regions includes those with high rates of conversion as well as those with low rates, but with rates that are not low enough to be categorised as negligible risk. The level of exposure to deforestation will vary within at-risk countries or subnational units in a country. For instance, a country representing 15% of global commodity deforestation has a higher risk than one representing only 1%, although both countries are categorised as at risk. Both countries should not be considered deforestation-free, but efforts to tackle deforestation should be concentrated in those countries and regions with the majority of commodity deforestation.

Difference between conversion and deforestation: We used commodity-specific deforestation data due to the unavailability of commodity conversion data. In the national cattle deforestation risk analysis, the method includes safeguards to address this limitation where we identified countries with significant cattle production and high rates of ecosystem conversion to all agricultural uses. This is because cattle may contribute to the conversion of other wooded lands and grasslands, but cannot be identified using the commodity deforestation data.

Period considered for the analysis: To develop our risk categorisation method, we relied on the most recent cattle deforestation data available. We aimed to ensure that all countries with potential exposure to deforestation and conversion were included in our analysis. The choice of period depends on the specific application of the deforestation/conversion risk assessment. For instance, if the goal is to assess the risk for a specific cut-off date, the assessment should consider the deforestation/conversion taking place after that cut-off date.

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Contact us

For further information contact
info@trase.earth

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