

- 1. Which geographic area of interest (AOI) are you focusing on? This can be the same AOI you selected for written assignment 1, or you can focus on a new AOI.**

The Atlantic Forest (Mata Atlântica) in Brazil

- 2. What role does your AOI play in global emissions? Is it associated with significant emissions? If so, which specific GHGs? And has this changed much in recent years? If your AOI emissions are insignificant because it is geographically very small, then apply these questions at the regional or national level of your AOI.**

The Atlantic Forests acts as a carbon sink, sequestering more carbon than is emitted by natural or human-caused activities. A 2023 study found that above-ground carbon stocks in the Atlantic Forest are on average 98.5 Mg C ha⁻¹ across all forest ages, with a carbon sink of 1.8 Mg C ha⁻¹ yr⁻¹ from 2009 to 2020 (Campos-Silva, 2023). According to SEEG, the Atlantic Forest sequestered 1.25 GtCO₂e between 2000 and 2018 (Fundação SOS Mata Atlântica, 2021).

Estimates of GHG emissions in the Atlantic Forest are provided by the Greenhouse Gas Emissions and Removals Estimating System (SEEG), an independent Brazilian organization. SEEG tracks GHG emissions across agriculture, energy, and use change, industrial processes and waste using data from over 5,000 municipalities in Brazil. SEEG covers carbon dioxide (CO₂), methane (CH₄), nitrous oxide (NO₂), and hydrofluorocarbons (HFCs)(SEEG, 2024).

Between 2000 and 2018, emissions in the Atlantic Forest region (including major cities like Sao Paulo and Rio de Janeiro) were 8.5 GtCO₂e (Fundação SOS Mata Atlântica, 2021). This accounted for 21 percent of the country's total emissions during this period. The sectors with the largest emissions were energy (37%), agriculture (32%), and land-use change and forestry (17%)(Fundação SOS Mata Atlântica, 2021).

For the next 3 questions, either choose the country where your AOI is located or where you live.

- 3. What gasses and economic sectors are included in the national GHG inventory of your country?**

Brazil is one the highest GHG emitters in the world, accounting for 4 percent of global emissions. According to the International Energy Agency, the transport sector accounted for 51% of CO₂ emissions in Brazil in the year 2022, followed by the industry sector (22%) and electricity and heat producers (12%).

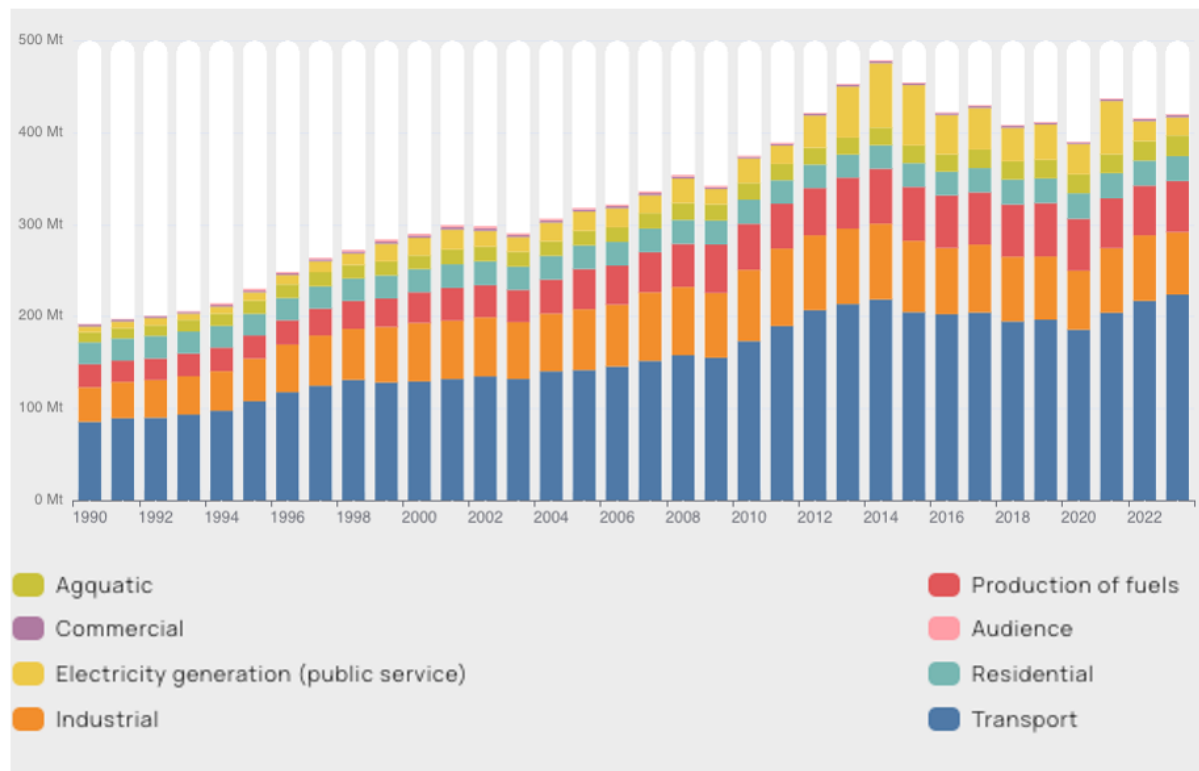
CO₂ emissions by sector, Brazil, 2022 (Data Source: IEA)

Sector	Mt CO ₂	Percentage
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Transport Sector	212.576	51%
Industry Sector	89.223	22%
Electricity and heat producers	50.414	12%
Other energy industries	21.082	5%
Agriculture/Forestry	20.146	5%
Residential	18.031	4%
Commercial and Public Services	2.46	1%
Total	413.932	100%

Historically, metric tons of carbon dioxide equivalent (MtCO₂e) emissions have increased from about 191 MT in 1990 to about 420 MT in 2023. By sector, the transportation sector continues to be the largest source of emissions, followed by the industrial sector and the production of fuels. There has been a two-fold increase in the net carbon emissions related to LULCC and forestry from 2017 and 2022 (SEEG, 2023). Most of these increases can be attributed to the removal of old-growth vegetation in the Amazon and Cerrado biomes (Dutra, 2024).

Figure 1. MtCO₂e in Brazil from 1990 to 2023, by sector (Source: SEEG)



4. What is the current status of your country's NDC? How many versions/generations have been submitted, and when is the next submission planned?

Brazil updated its Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC) in October 2023. The NDC sets an absolute reduction of greenhouse gas (GHG) emissions of 48.4 percent (1.32 GtCO₂e) compared to 2005 and a net reduction of 53.1 percent (1.2 GtCO₂e) compared to 2005 (Federative Republic of Brazil, 2023).

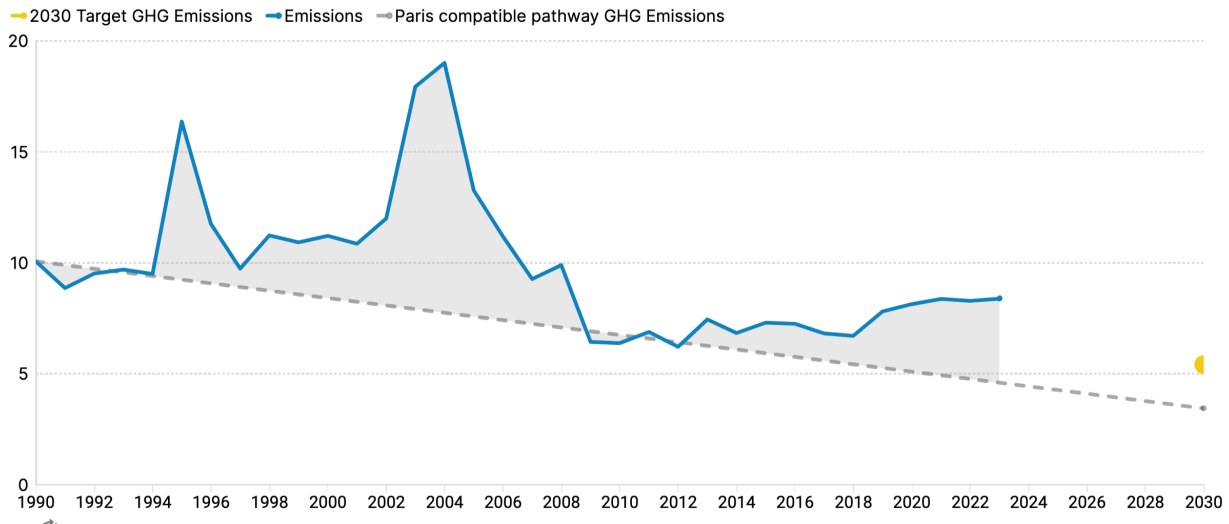
Brazil made an initial NDC submission in 2016 and has filed three updates in 2020, 2022, and 2023. Emissions goals from its initial submission have not become more ambitious since its original submission. Reforestation goals outlined in the initial NDC (12 Mha of forests by 2030) were scrapped in subsequent submissions (Dutra, 2024). Vegetation regrowth in Brazil from 2017 to 2022 covered 5.46 Mha, or about half of the targeted amount from the first NDC (Dutra, 2024).

5. Choose one climate watchdog mentioned in Lecture 2. How does your country fare when evaluated according to their rubric? What is responsible for these ratings? Do you believe they are warranted? Why or why not?

The Climate Change Performance Index (CCPI) gave Brazil a rank performance of “medium” in 2025. It cites an improvement in Brazil's climate policy since Lula da Silva took office in 2023 and its updated NDC with 2035 targets (CEEPI). It cites its reliance on fossil fuels as a weak point, with support for new oil and gas ventures with governmental subsidies. Coal subsidies are set to remain in place until 2040 (CEEPI).

The figure below shows the current emissions trajectory compared to one that targets the Paris agreement, showing that Brazil's emissions are about 3.78 tCO₂e per capita higher than the target goal in 2022.

Figure 2. Paris compatible pathway and 2030 target compared with current development (Source: CEEPI)



6. Can you list out one or more Natural Climate Solutions (NCS) that you think would have the largest impact on climate change mitigation within your AOI? E.g. forest conservation, wetland restoration, etc. Briefly explain why you think they would be the most impactful within your AOI.

Reforestation has been highlighted as a cost-effective, high-impact NCS solution in the Atlantic Forest. A study aiming to rank restorable areas—defined as those with an elevation below 1000m, with under 90% tree canopy cover, and not covered by urban areas, water bodies, and wetlands—found that the Atlantic Forest has one of the highest reforestation potentials worldwide (Brancalion et al., 2019). About 40 million hectares can be restored in the Atlantic Forest, or roughly the same area as Norway (Brancalion et al., 2019).

The Atlantic Forest has been deforested for over 500 years, now only having about 8 percent of its original area. LULC analysis shows that areas that were forest are now croplands or pasture (see submission for Module 1). In addition, remaining forest areas are highly fragmented. Under these conditions, I believe that afforestation (rather than reforestation or restocking) would have the biggest impact as a NCS in the Atlantic Forest.

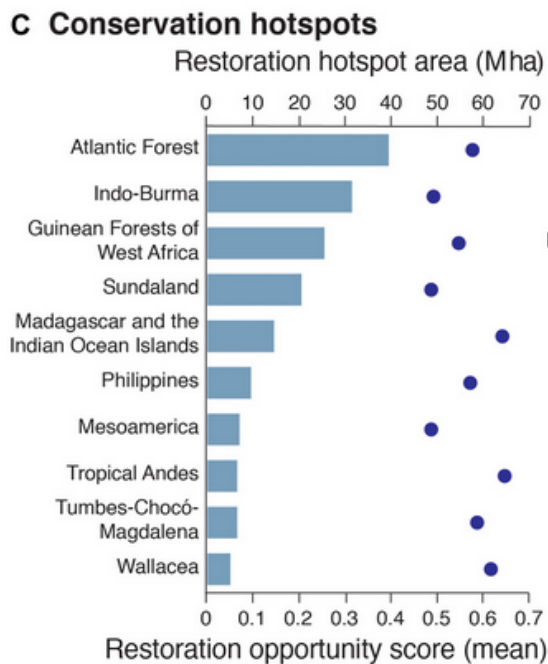
Piffer et al. (2021) highlight challenges in the reforestation of the Atlantic Forest using 35 years of land cover data. Deforestation reversals were prevalent in urbanized municipalities with high agricultural productivity. This study highlights the importance of free and informed prior consent in communities that are involved in afforestation efforts and payment mechanisms that make it economically feasible to reforest former agricultural land.

7. For forest NCS applicable to your AOI, which co-benefits (non-carbon elements beyond wood, timber, and carbon) are of most interest/importance to you? Do

you foresee any tradeoffs (negative outcomes) that would occur if these NCS were implemented in your AOI? How might those be mitigated?

Because of its status as a biodiversity hotspot, the conservation and protection of wildlife is an important secondary effect of forest NCS in the Atlantic Forest. Brancalion et al. (2019) identified the Atlantic Forest as a conservation hotspot with the highest restoration potential of any biome in the world.

Figure 4. Top ten conservation hotspots by million-hectare meter (Mha) and their average restoration opportunity score (Source: Brancalion et al., 2019)



Potential negative consequences to optimizing for afforestation that benefits wildlife includes a higher cost of procuring seedlings; additional thought and planning associated with certain species planting; and potentially lower carbon credits by favoring native species rather than faster growing, non-native species (eg. Eucalyptus).

These risks can be mitigated by focusing on natural regeneration with select species. Some studies have shown that prioritizing fruiting species that attract wildlife for seed dispersal of rarer species can be an effective method of introducing additional tree species that were not originally planted (Wunderle, 1997). Estrada-Villegas et al. (2022) studied animal seed dispersal by flightless mammals, large birds, small birds, and bats in central Panama, finding that young regenerating forests were made up by trees dispersed by small birds, with larger birds and terrestrial mammals playing a larger role in tropical forests from 20 years old to old growth. This approach can bring costs down and reduce the human effort associated with tracking and planning rarer species.

8. Does your country participate in REDD+? If so, how? Does your country support REDD+ in any other way (financing, expertise, research etc)? If so, how?

In 2015, Brazil adopted a national REDD+ strategy (known as ENREDD+) with a focus on preventing deforestation and forest degradation, promoting forest recovery, and promoting a sustainable development strategy (MMA, 2016). The document was adopted after consultations with stakeholders between 2010 and 2015. The REDD+ strategy focused on the Amazon and Cerrado biomes with specific Action Plans for both areas (PPCDAm and PPCerrado, respectively) (Brazil Ministry of the Environment, 2016). The Amazon Fund and the National Climate Change Fund are the main Brazilian mechanisms for financing the country's REDD+ efforts (MMA, 2016). The National REDD+ Committee (CONAREDD+) is responsible for overseeing and monitoring the National REDD+ strategy (MMA, n.d).

According to the ENREDD+ national strategy, the country's three main national objectives are:

- Coordinating climate change, biodiversity and forest related public policies: drafting an impact and results assessment matrix for climate change, biodiversity, and forest-related public policies
- Measuring, reporting and verifying results: establishing reference levels, submitting to the REDD+ Technical Annex
- Fundraising for REDD+ results-based payments and distributing benefits:

Brazil submitted its proposed forest reference emission level (FREL) and forest reference level (FRL) to the UNFCCC in 2023. The submission was modified and published in 2024 (UNFCCC, 2024).

9. What were your primary sources of information for answering these questions? Which of these questions (if any) were the most difficult to answer and why?

My primary sources were documents from the Brazilian Ministry of the Environment, academic articles, and independent organizations that track GHG emissions. Historical and sectorally broken down GHG emissions were the hardest to access for local areas like the Atlantic Forest.

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