Project Progress Report

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November 6, 2024

1 Introduction

Deforestation in the Amazon rainforest has long been a critical environmental issue, with significant implications for biodiversity, climate change, and global ecosystems. The Amazon, often referred to as the "lungs of the Earth," plays a pivotal role in regulating the global climate, and its deforestation directly contributes to the acceleration of climate change. Our project investigates the potential factors like El Niño, La Niña, forest fires etc. that might be imacting the deforestation in the Amazon region.

Through an analysis of deforestation trends across nine states in Brazil between 2004 and 2019, we seek to identify correlations between climate events and deforestation patterns. The project also aims to understand the spatial and temporal variation in deforestation across different regions of the Amazon, shedding light on areas that have seen the greatest environmental impact. By examining the deforested area over time and comparing it to the occurrence of global climate phenomena, this study aims to provide insights into the environmental factors that may drive deforestation.

2 Assumptions & Criteria

In this analysis,it is assumed that El Niño and La Niña events have an observable impact on deforestation in the Brazilian Amazon. Furthermore, it is assumed that no significant policy changes during the 2004-2019 period had a major impact on deforestation patterns, and that the effects of climate phenomena are uniform across the nine states in the Brazilian Amazon included in the dataset. The analysis assumes that the effects of climate events (e.g., El Niño and La Niña) are homogeneous across all states in the Amazon. In reality, the impacts of these events may vary by region, but this assumption simplifies the analysis by treating the effects uniformly across the states.
The criteria for selecting the time period and geographic scope for this analysis were based on the availability of data for the period 2004-2019, which provides a comprehensive view of deforestation trends and climate phenomena over a significant period. The nine Brazilian states included—Acre, Amazonas, Amapá, Maranhão, Mato Grosso, Pará, Rondônia, Roraima, and Tocantins—were selected due to their importance in the context of deforestation in the Amazon region.

3 Data

3.1 Sources

The two primary datasets used in this study were sourced from well-established, publicly accessible platforms:

Deforestation Data (def_area_2004_2019.csv): The deforestation data, spanning from 2004 to 2019, was extracted from the INPE website. The data is already aggregated, meaning it has been processed and structured for use. The deforestation monitoring was carried out using the PRODES (Programa de Monitoramento da Floresta Amazônica Brasileira por Satélite) program. PRODES monitors primary forest loss in the Brazilian Amazon using satellite imagery with a spatial resolution of 20 to 30 meters and a 16-day revisit rate. The methodology used by PRODES ensures high precision in forest loss detection while accounting for cloud cover interference. This dataset provides annual records of deforested areas across

nine Brazilian states—Acre, Amazonas, Amapá, Maranhão, Mato Grosso, Pará, Rondônia, Roraima, and Tocantins—measured in square kilometers.

Climate Data (el_nino_la_nina_1999_2019.csv): The climate dataset spans from 1999 to 2019 and includes data on the onset, duration, and severity of El Niño and La Niña, two of the most significant climate phenomena. The data was obtained from Golden Gate Weather Services, which provides detailed records on climate events. Each record includes the start year, end year, and severity level (Weak, Moderate, Strong, Very Strong) of the climate events, allowing for a comparison of the timing and intensity of El Niño and La Niña occurrences in relation to deforestation events.

3.2 Data Characteristics

3.2.1 Data Format

Both datasets are provided in CSV (Comma Separated Values) format. This format is commonly used for tabular data and is ideal for handling time-series and spatial-temporal datasets.

3.2.2 Variables

Deforestation Dataset:

- **Year:** The year in which deforestation was recorded.
- **Deforested Area (km^2):** The total area of the Amazon rainforest that was deforested in all 9 states, measured in square kilometers.
- **State:** The Brazilian state in which the deforestation occurred.

Climate Dataset:

- **Phenomenon:** El Niño or La Niña, whichever occurred.
- **Start Year:** The year when the El Niño or La Niña event began.
- **End Year:** The year when the event ended.
- **Severity:** The severity of the climate phenomenon (Weak, Moderate, Strong, Very Strong).

4 Visualisations & Analysis

Upon reviewing the deforestation data, it was observed that 2004 marked a particularly severe year for deforestation across the Amazon states. Following this peak, the deforested area showed a downward trend until 2012. However, after 2012, deforestation began to rise again, particularly in certain states. This suggests that, while there may have been short-term improvements, long-term deforestation trends have fluctuated over the years.

In particular, Mato Grosso experienced the most significant decline in rainforest area from 2004 onwards, showing a dramatic reduction in deforestation over time. Pará and Rondônia also saw substantial declines in deforestation, ranking third in terms of the total area affected. On the other hand, Tocantins and Amapá showed relatively insignificant changes in deforestation. This may be due to the fact that these states had lower initial forest cover, and thus the relative impact of deforestation was less pronounced compared to other states. Once deforestation occurred, the remaining forest area in these regions was smaller, leading to less noticeable changes in the overall deforestation figures.

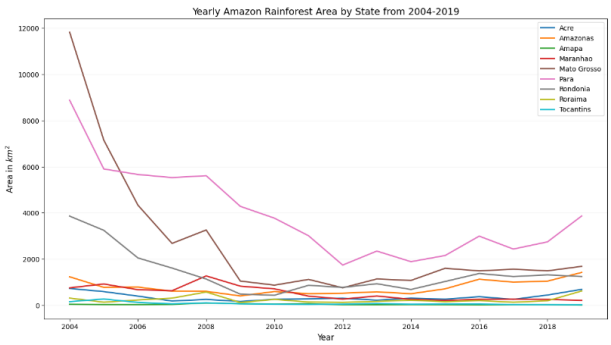

Figure 1: Yearly deforested Amazon Rainforest Area by State from 2004-2019

4.1 State-wise analysis of deforestation

To gain a clearer understanding of these trends, the deforested area for each state was plotted separately. This allowed for a visual comparison of the deforestation patterns across different regions, providing valuable insights into which states were most affected over time.
From 2004 to 2012, while many states experienced a decline in deforestation, it is evident that not all regions followed this downward trend. Specifically, Amapá, Maranhão, and Roraima saw an increase in deforestation during this period, suggesting that various factors such as local land-use practices, economic pressures, or policy enforcement could have influenced these regional variations. The rising deforestation in these states indicates a potential divergence from the broader trend of deforestation reduction observed in other areas of the Amazon during the same timeframe.

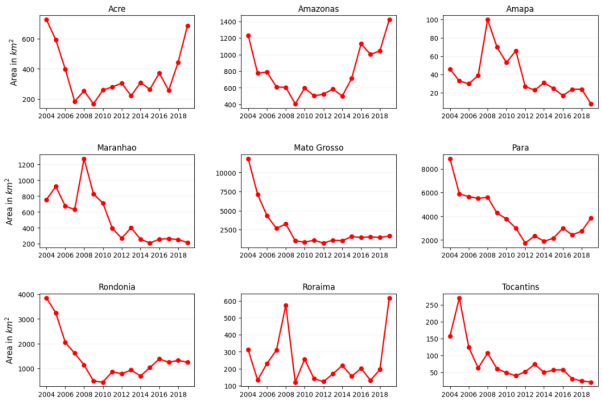

Figure 2: Yearly Deforested Amazon Area in each State from 2004-2019

4.2 Aggregated Deforested area over the years

When aggregating the deforested areas across all nine states, we observe that deforestation in the Amazon experienced notable fluctuations over the years. From 2004 to 2012, there was an overall downward trend in forest loss, suggesting that conservation efforts, policy changes, or external factors may have contributed to a reduction in deforestation during this period. However, after 2012, the trend reversed, with a consistent increase in deforestation across the region. This uptick in forest loss post-2012 highlights a worrying trend, where despite prior reductions, deforestation has started to accelerate once again, pointing to the potential resurgence of factors driving environmental degradation in the Amazon.

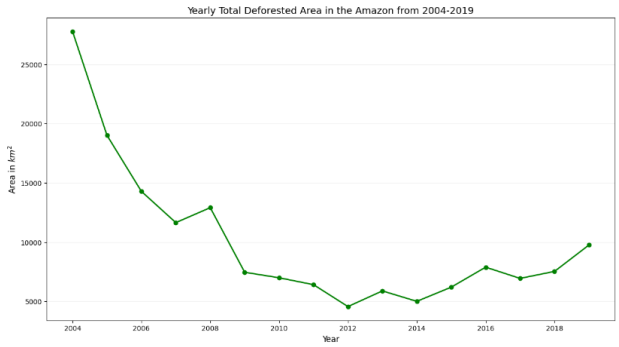

Figure 3: Aggregated Deforested area over the years

4.3 Total Deforested Area in each State

When examining the total deforested area on a state-by-state basis from 2004 to 2019, Pará stands out as the state with the highest deforestation over the period. This suggests that Pará has experienced significant environmental pressures leading to substantial forest loss. In contrast, Amapá had the least deforestation, indicating that its forest cover has been less impacted compared to other states, potentially due to lower rates of deforestation activities or stronger conservation measures.
As part of our investigation, we will further explore the role of fires in deforestation, particularly in Pará, to determine whether the state's high deforestation rates can be attributed, in part, to a large number of fires that may have accelerated the loss of tree cover. This analysis will help identify whether fire events have been a key factor in deforestation patterns in the region.

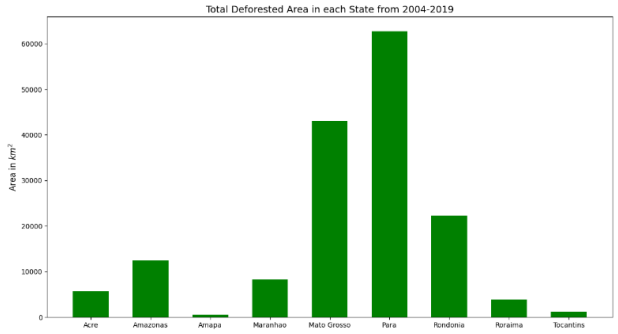

Figure 4: Total Deforested Area in each State from 2004-2019

4.4 Impact of El Nino and La Nina

El Niño and La Niña are two opposing climate phenomena that significantly influence weather patterns, particularly in the Amazon rainforest. El Niño is associated with warmer-than-average sea surface temperatures in the central and eastern Pacific Ocean, which disrupts atmospheric patterns. In South America, El Niño brings dry conditions, which increase the likelihood of forest fires in the Amazon. These conditions make it easier for fires, both natural and human-induced, to spread and become uncontrollable. The dry spell during El Niño years worsens deforestation, as fires can destroy large areas of forest. In regions where fire management is insufficient, the spread of uncontrolled fires exacerbates environmental damage.

On the other hand, La Niña is characterized by cooler-than-usual sea surface temperatures in the central and eastern Pacific, leading to wetter conditions in the Amazon. The increased rainfall associated with La Niña reduces the frequency and intensity of forest fires, as higher moisture levels make it less likely for

fires to start or spread. These wet conditions are generally beneficial for the Amazon, as they help to reduce fire-related damage and support the preservation of the rainforest.

In this analysis, we will examine the years and severity of El Niño and La Niña events to explore whether there is any correlation between these climate phenomena and deforestation rates in the Brazilian Amazon. The chart below shows the occurrence and intensity of these events across the years, which can help us understand how they relate to the deforestation patterns observed during those periods.

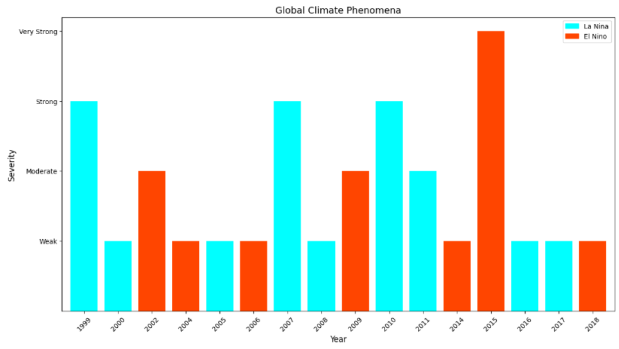

Figure 5: Global phenomenon vs Severity

When we overlay the deforestation trend line with the severity of El Niño and La Niña, using the transparency of the bars to indicate the intensity of each event, we can assess whether there is any observable correlation between these climate phenomena and deforestation rates. However, after analyzing the data, it becomes evident that there is no clear correlation between the two factors. The deforestation rate does not consistently increase or decrease following either an El Niño or La Niña event.

While it might be expected that El Niño, with its dry conditions, would lead to an increase in deforestation

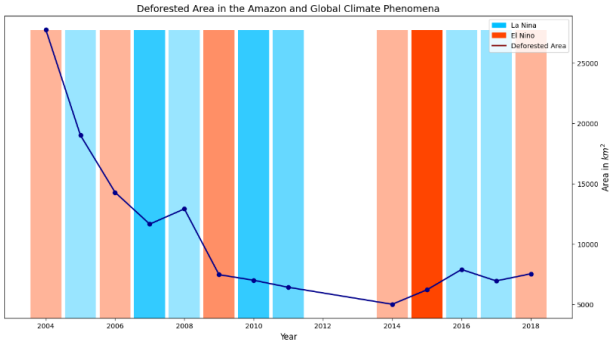

Figure 6: Deforested Area in the Amazon and Global Climate Phenomena

due to more frequent and intense fires, and La Niña, with its wet conditions, would help reduce deforestation by limiting fire risks, the data suggests that other factors may be at play. The transparency of the bars indicating the severity of each phenomenon does not show a strong link to fluctuations in deforestation, implying that deforestation in the Amazon may be influenced by a range of other variables—such as land-use policies, illegal logging, agricultural expansion, and socio-economic factors—that are not directly tied to El Niño and La Niña events.

5 Plan ahead

To enhance the analysis of deforestation in the Amazon, another key factor to consider is the impact of fire spots and fire outbreaks. Fire is a significant driver of deforestation, particularly during dry conditions such as those brought by El Niño. By incorporating fire data, we can analyze how fire outbreaks contribute to forest

loss over the same period (2004-2019) in the nine states. This data can be overlaid on the deforestation trend lines to examine if there are any correlations between fire activity and forest loss. Additionally, statistical methods can be used to determine the strength of the relationship between fire intensity and deforestation, while also assessing the interaction between fire events and climate phenomena like El Niño and La Niña. It's important to investigate whether fire outbreaks tend to spike during El Niño years due to the dry conditions, or whether they occur independently of climate patterns. Ultimately, this analysis will provide a clearer picture of the role fires play in Amazonian deforestation, helping to identify the need for effective fire management strategies in mitigating forest loss.