PROJECT: CARBON EMISSIONS FROM FIVE COUNTRIES WITH THE LARGEST FOREST FROM 1990 TO 2019

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What is Carbon Emission ?

What is carbon emission and why is it bad ?

Carbon dioxide is a problem because it acts as a “greenhouse gas”. Due to its molecular structure, CO2 absorbs and emits infrared radiation, warming the earth’s surface and the lower levels of the atmosphere. Source: inspirecleanenergy

What causes carbon emission ?

Direct emissions are produced by burning fuel for power or heat, through chemical reactions, and from leaks from industrial processes or equipment

Problem Introduction

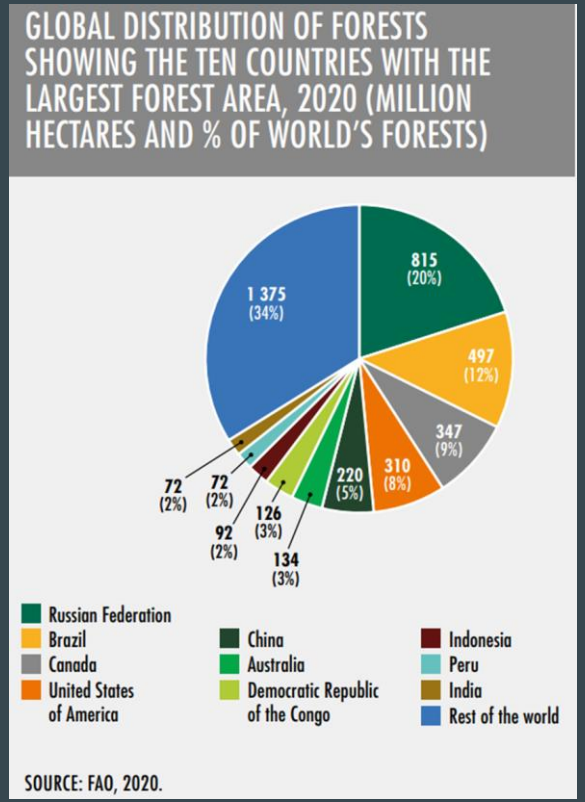
- The impact of climate change has begun to be felt very quickly in recent years. The leading cause of climate change is global warming due to excessive greenhouse gas emissions.
- Greenhouse gases occur naturally in the atmosphere, but with human activities, the amount of these gases increases.
- Several types of gases, such as carbon dioxide, methane, and nitrous oxide, are one of the leading causes of global warming.
- The development of science and technology has encouraged human activities in exploiting available natural resources such as forests. One example is the conversion of forest land into residential, industrial, food, and other sectors.
- According to FAO (2020) :
    - “Since 1990, it is estimated that 420 million hectares of forest have been lost through conversion to other land uses, although deforestation has decreased over the past three decades. Between 2015 and 2020, the rate of deforestation was estimated at 10 million hectares per year, down from 16 million hectares per year in the 1990s. The area of primary forest worldwide has decreased by over 80 million hectares since 1990.”

Problem Overview

The impact of climate change has begun to be felt very quickly in recent years, which is none other than the leading cause of global warming.

Global warming increases the earth's temperature by the emission of greenhouse gases, such as carbon dioxide, methane, and nitrous oxide.

It is necessary to record the footprint of greenhouse gas emissions (mainly carbon) in every country to reduce the level of greenhouse gas emissions



Goal and Objective

Goal

The main goal is to calculate the track record of the number of carbon emissions of each country, especially in countries with the potential to have high carbon emissions.

Objective

The objective is to visualise greenhouse gas emissions every year based on the track record of each country, along with the causes for carbon emissions (mainly from forest-related).

About Dataset

The data source : https://www.kaggle.com/datasets/ankitpranay/global-emissions-from-agriculture-and-forest-land

```
pd.read_csv('FAOSTAT_data_1961_2019.csv')
```

	Area Code	Area	Item Code	Item	Element Code	Element	Source Code	Source	Unit	Y1961	...	Y2010	Y2011	Y2012
0	2	Afghanistan	5058	Enteric Fermentation	7225	Emissions (CH4)	3050	FAO TIER 1	kilotonnes	240.6831	...	401.068	402.513	396.921
1	2	Afghanistan	5058	Enteric Fermentation	7225	Emissions (CH4)	3051	UNFCCC	kilotonnes	NaN	...	NaN	NaN	NaN
2	2	Afghanistan	5058	Enteric Fermentation	724413	Emissions (CO2eq) from CH4 (AR5)	3050	FAO TIER 1	kilotonnes	6739.1279	...	11229.904	11270.364	11113.788
3	2	Afghanistan	5058	Enteric Fermentation	724413	Emissions (CO2eq) from CH4 (AR5)	3051	UNFCCC	kilotonnes	NaN	...	NaN	NaN	NaN

```
# Import all modules needed
import pandas as pd
import numpy as np
import regex as re
import seaborn as sns
import matplotlib.pyplot as plt
import geopandas
import matplotlib.colors
import pycountry
```

Module used in this project

About Dataset

There are 68 columns and 33434 column in the dataset, that is :
Area Code, Area, Item Code, Item, Element Code, Element, Source Code, Source, Unit, and years from Y1961 to Y2019.

Area: countries of the world
Area Code: country code
Item: causes of carbon emission
Item Code: code for each cause of carbon emission
Element: each type of element that causes carbon emissions
Source code: code for data source
Source: data source

Unit: Emissions from single gases (NH4, N2O, CO2) AND totals (CO2) in kilotonnes (kt)
Y1961 - Y2019: time coverage

Checking the Duplicated and Null Values

There are 59 rows that have null values, that is years column from Y1961 to Y2019. Also, there are no duplicate column detected.

```
# Checking the null values
pd.options.display.max_rows = None
print("There are {} null values in the dataset".format(fao.isna().any().sum()))
print("There are {} duplicate rows".format(fao.duplicated().any().sum()))
```

```
There are 59 null values in dataset
There are 0 duplicate rows
```

Data Cleaning

Handling Missing Value

```
def fillna(series):
    if series.dtype is pd.np.dtype(float):
        return series.fillna(0)
    elif series.dtype is pd.np.dtype(object):
        return series.fillna('-')
    else:
        return series
```

Mostly the null value was detected in the year column from Y1961 to Y1990, maybe at that time there was no adequate technology to record carbon emissions on regular basis.

If the data type on specific column is object we fill the null values with "-" and if the data type is float we fill the null with 0

Data Cleaning

Change the Column Name

```
fao.columns = fao.columns.str.replace(' ','_')
fao.columns = fao.columns.str.replace('Y','')
fao.head()
```

"Y" in "Y1961" indicates the year

Rename the column to contain only the year, remove the "Y" from the year column name. Also, we remove spaces with "_".

Selected Data

1. The country that we pick based on the country with the largest forest area, that is **Brazil, Canada, Congo, Indonesia, and India.**
2. We focus to analyze **CO2(eq)(AR5)** emitted by some event such as **drained organic soils, fires in humid tropical forest, forest in organic soils, forestland, LULUCF, and savana fires.** We analyze how much every causes of carbon emissions affected the amount of CO2(eq)(AR5) at some country.

Item	year	Drained organic soils	Fires in humid tropical forests	Fires in organic soils	Forestland	LULUCF	Savanna fires
0	1990	6898.2268	1035.9269	40.154	-227396.9133	-216935.2622	326.3114
1	1991	6898.2268	1035.9269	40.154	-227396.9133	-216935.2622	326.3114
2	1992	6898.2268	1035.9269	40.154	-227396.9133	-216935.2622	326.3114
3	1993	6898.2268	1035.9269	40.154	-227396.9133	-216935.2622	326.3114
4	1994	6901.5027	1035.9269	40.154	-227396.9133	-216932.2556	326.3114

Example dataset for **Brazil**

Selected Data

3. Additionally, we analyze **all green house gasses** that contain in dataset for every country

Element	year	Direct emissions (N2O)	Emissions (CH4)	Emissions (CO2)	Emissions (CO2eq) (AR5)	Emissions (CO2eq) from CH4 (AR5)	Emissions (CO2eq) from N2O (AR5)	Emissions (N2O)	Indirect emissions (N2O)
0	1990	1983.2369	87288.1855	-546146.1001	2.619049e+06	2.444069e+06	714227.9255	2695.1997	584.8440
1	1991	2039.7761	88016.2526	-540615.8958	2.665425e+06	2.464455e+06	734687.6374	2772.4061	602.9124
2	1992	2099.3202	88528.7121	-541381.6177	2.699903e+06	2.478804e+06	755582.9120	2851.2565	620.8338
3	1993	2147.5537	89249.8836	-532288.0162	2.746576e+06	2.498997e+06	772968.9024	2916.8637	635.8266
4	1994	2228.0694	114035.3933	-530980.7102	3.550713e+06	3.192991e+06	881800.9384	3327.5507	661.6854

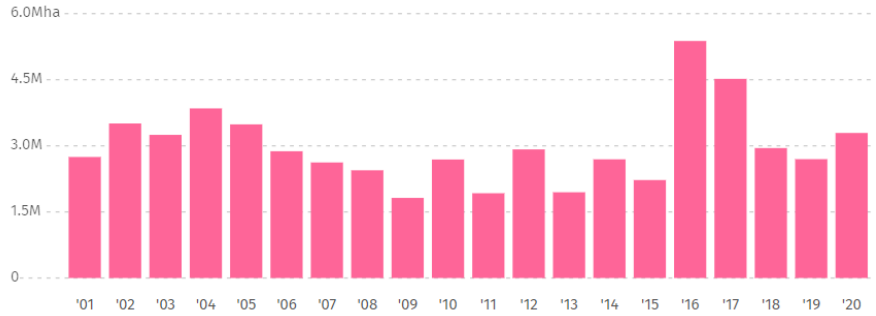
Example dataset for India

01
Brazil

The country with the second-largest forest area in the world.

According to **Global Forest Watch** :

- **In 2010**, Brazil had 492 Mha of natural forest, extending over 59% of its land area.
- **In 2020**, it lost 3.20Mha of natural forest, equivalent to 1.77 Gton of CO_2 emissions.

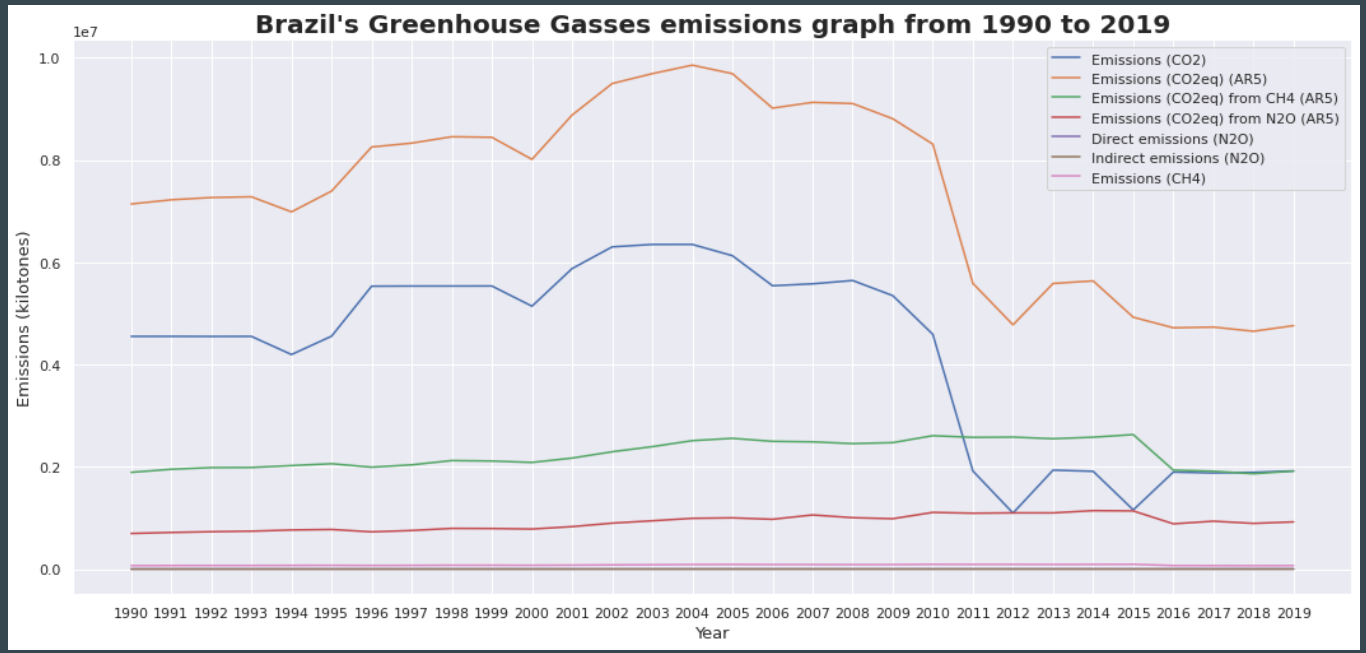


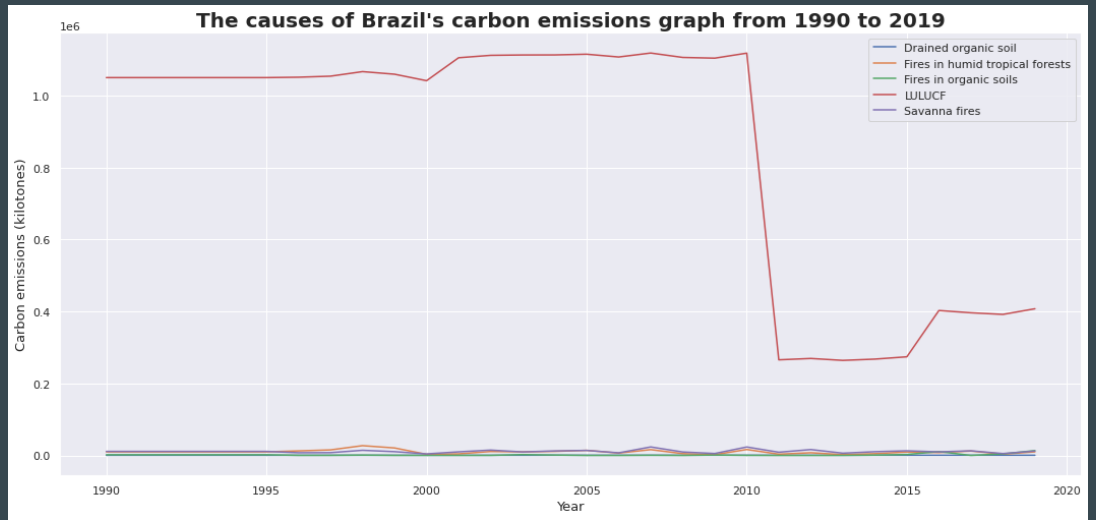
"From 2001 to 2020, Brazil lost 59.8Mha of tree cover, equivalent to a 12% decrease in tree cover since 2010, and 32.5Gt of CO_2 emissions."

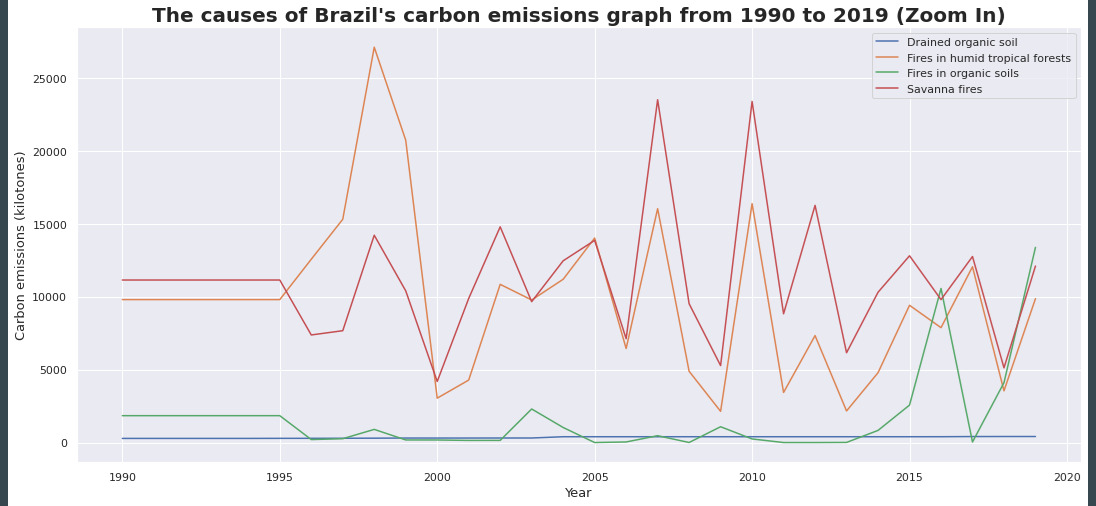
Source : Global Forest Watch

Brazil Analysis

Based on IPCC AR5, Brazil's carbon emissions have increased from the early 1990s to their highest peak in 2004. In 2010 the graph began to experience a drastic decline until 2012, then there was a slight increase but fluctuated around 5 million kilotons (5 gigatons) until 2019. From 1990-2019, the total of Brazil's carbon emission was around **137 Gigatonnes.**







- Based on the graph beside, the most significant cause of carbon emissions from Brazil is **LULUCF (Land Use, Land Use Change and Forestry)**, exceeding **100 gigatonnes** from 1990 to 2010. Brazil's LULUCF has **decreased** drastically to fluctuate at **300,000 kilotons (300 million tons)**.

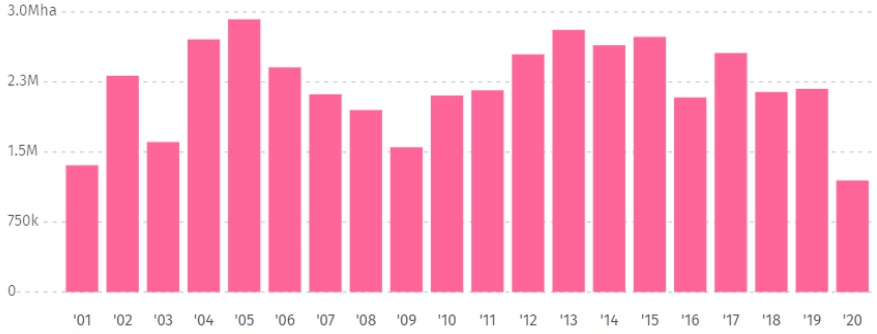
- Another cause of carbon emissions is **tropical forest and savanna fires**, which fluctuate between **5000** to **25000 kilotons** of carbon.

02
Canada

The country with the third-largest forest area in the world.

According to **Global Forest Watch** :

- **In 2010**, Canada had 420Mha of tree cover, extending over 47% of its land area.
- **In 2020,** Canada had lost 1.20Mha of tree cover.

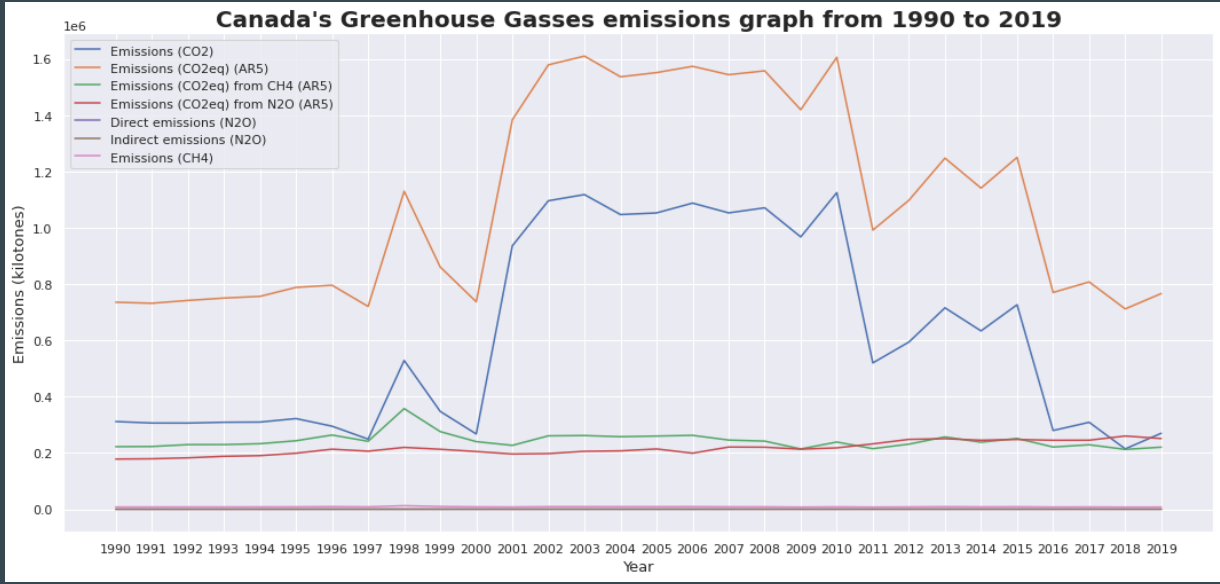


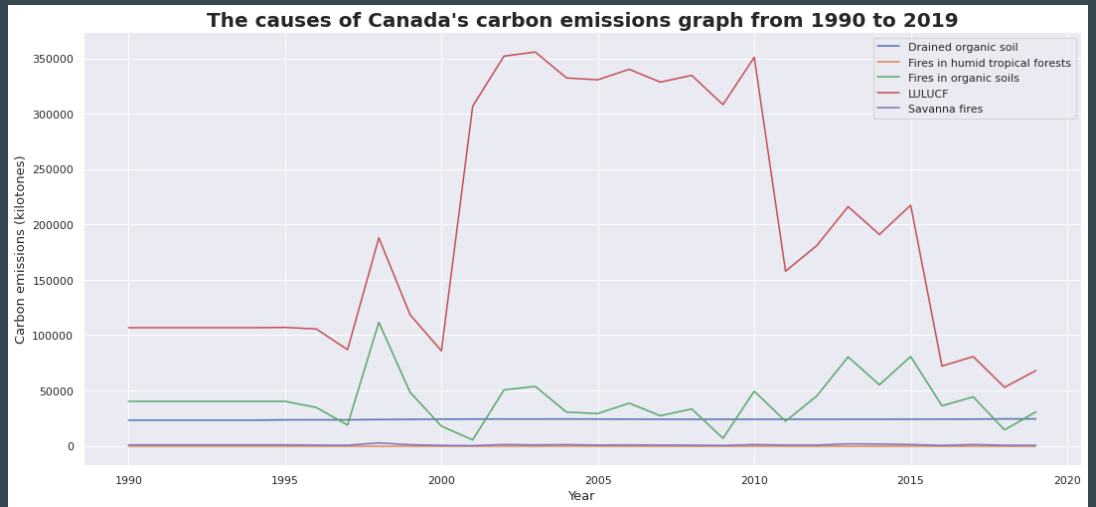
“From 2001 to 2020, Canada lost 44.1Mha of tree cover, equivalent to a 11% decrease in tree cover since 2000.”

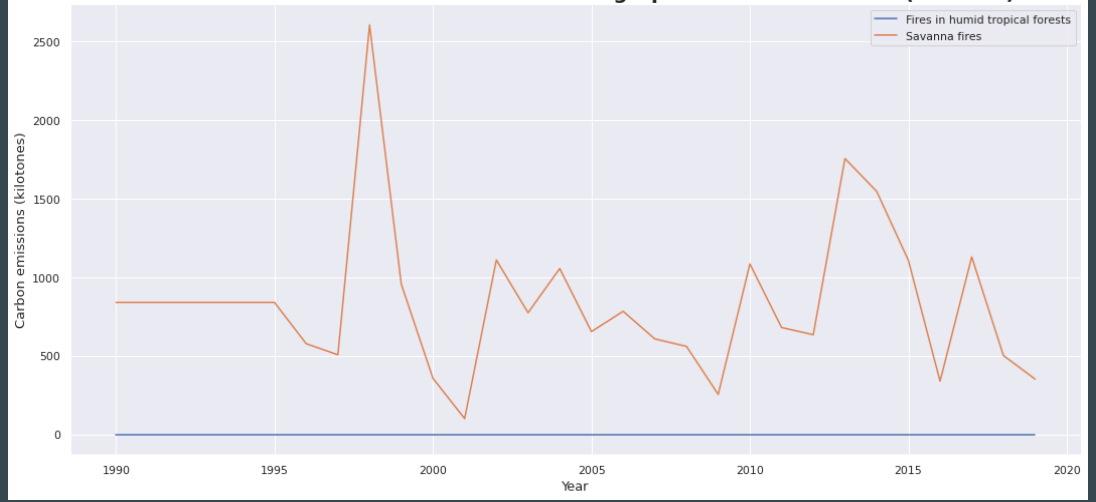
Source : Global Forest Watch

Canada Analysis

Based on IPCC AR5, Canada's carbon emissions have **increased sharply from 1997-1998**, then **decreased** again to **below 800 Megatons in 2000**. However, from 2001 to 2010 there was a significant increase in carbon emissions, reaching **1.6 Gigatonnes in 2003 and 2010.** In the following years, Canada's carbon emissions were still volatile in the following years until they finally stabilized back **below 800 Megatons in 2016-2019**. From **1990-2019, the total of Canada's carbon emission was around 24 Gigatonnes.**







- Based on the graph beside, the biggest cause of carbon emissions from Canada is **LULUCF (Land Use, Land Use Change and Forestry)** up to **350 Megatons**. The LULUCF graph closely resemble the graphic form of Canada's carbon emissions based on IPCC AR5.

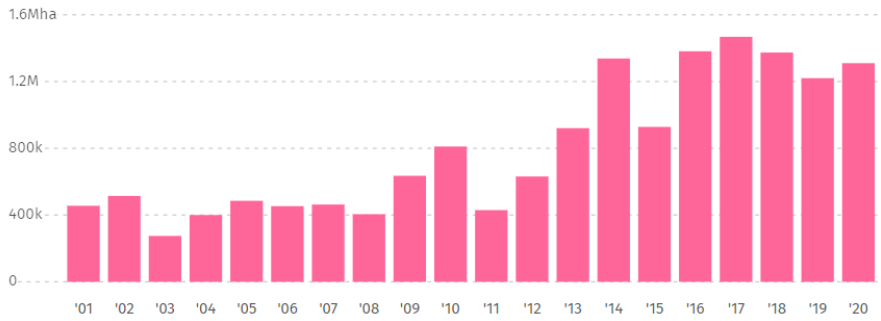
- Another cause of carbon emissions is the **drying and burning of organic soils**. While the **drying soil is steady at 25 Megatons**, the **burning soil fluctuates between 10-100 Megatons**.

03
Congo

The country with the sixth-largest forest area in the world.

According to **Global Forest Watch** :

- **In 2010,** Democratic Republic of the Congo had 198Mha of natural forest, extending over 85% of its land area.
- **In 2020,** it lost 1.31Mha of natural forest, equivalent to 854Mt of CO_2 emissions.

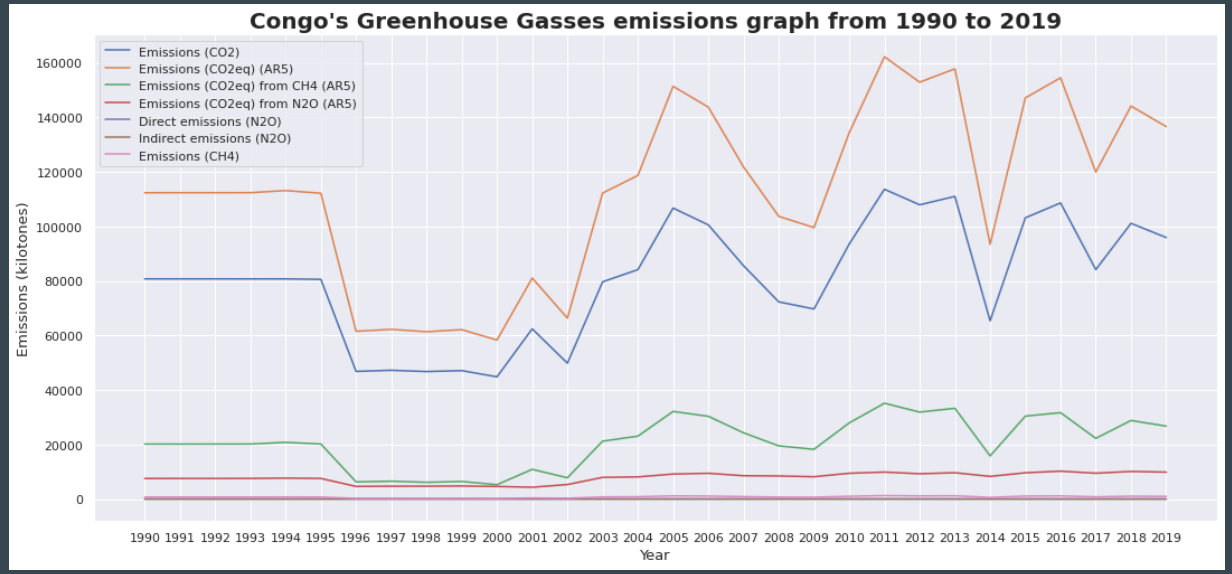


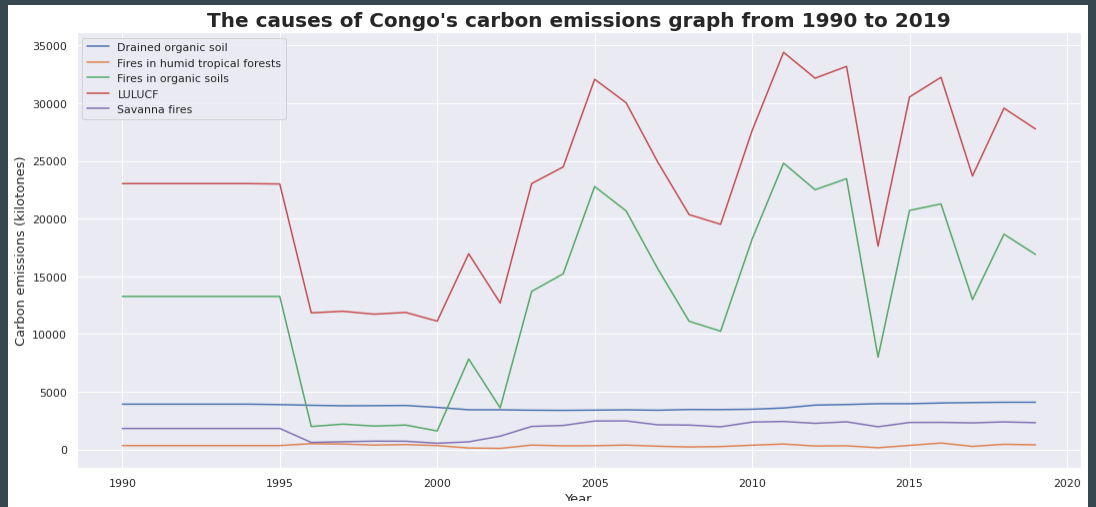
"From 2001 to 2020, Democratic Republic of the Congo lost 15.9Mha of tree cover, equivalent to a 8.0% decrease in tree cover since 2000, and 9.71Gt of CO_2e emissions.."

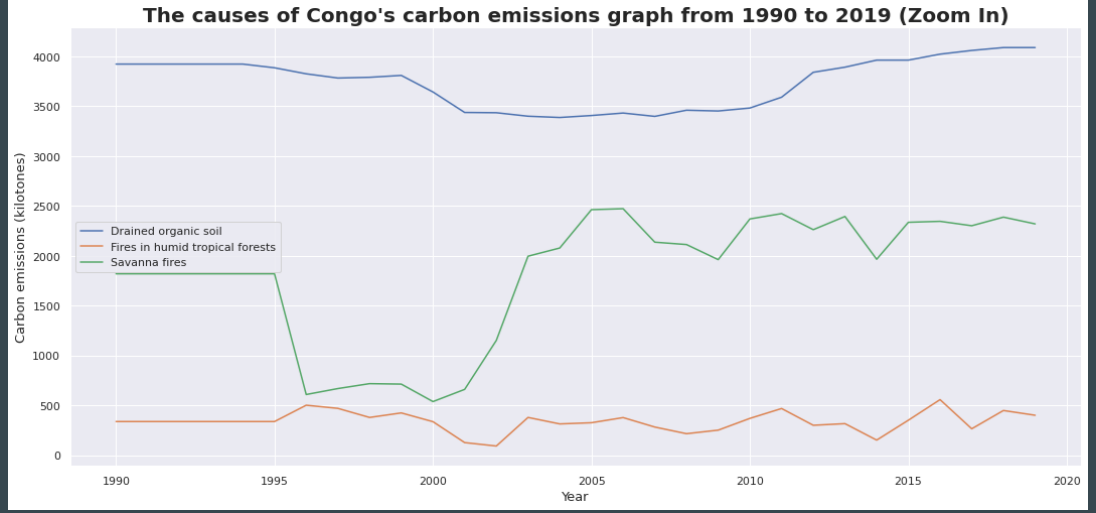
Source : Global Forest Watch

Congo Analysis

Based on IPCC AR5, Congo's carbon emissions in 1990-1995 were **stable at around 115 Megatons,** then **dasecreed** to almost **60 Megatons in 1996-2000**. The Congo's emissions again increased from 2001 to 2019, with the highest peak passing **160 Megatons in 2011**. **From 1990-2019, the total of Congo's carbon emission was around 2,4 Gigatonnes**.







- Based on the graph beside, the most significant cause of carbon emissions from Congo is **LULUCF (Land Use, Land Use Change and Forestry)** which reached almost **35 Megatons in 2011**. The LULUCF and organic soil burning graph closely resemble the graphic form of Congo's carbon emissions based on IPCC AR5.

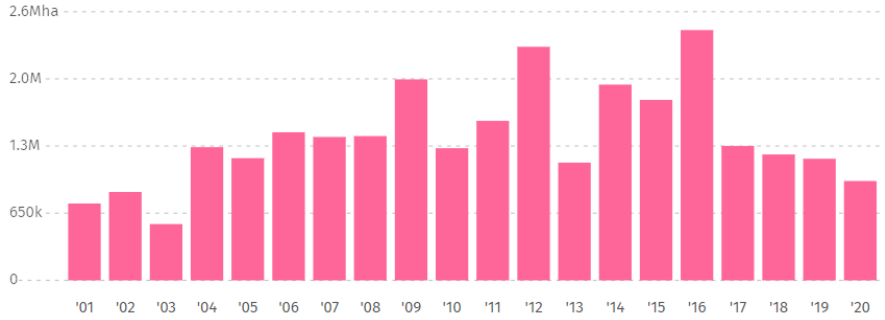
- Other causes of carbon emissions are caused by **drying of organic soil, tropical forest fires, and savanna fires** with emissions **below 5 Megatons**, which tend to be smaller than other causes of emissions.

04
Indonesia

The country with the eighth-largest forest area in the world.

According to **Global Forest Watch** :

- **In 2001,** Indonesia had 93.8 Mha of primary forest*, extending over 50% of its land area.
- **In 2020,** it lost 270 kha of primary forest*, equivalent to 208Mt of CO_2 emissions.

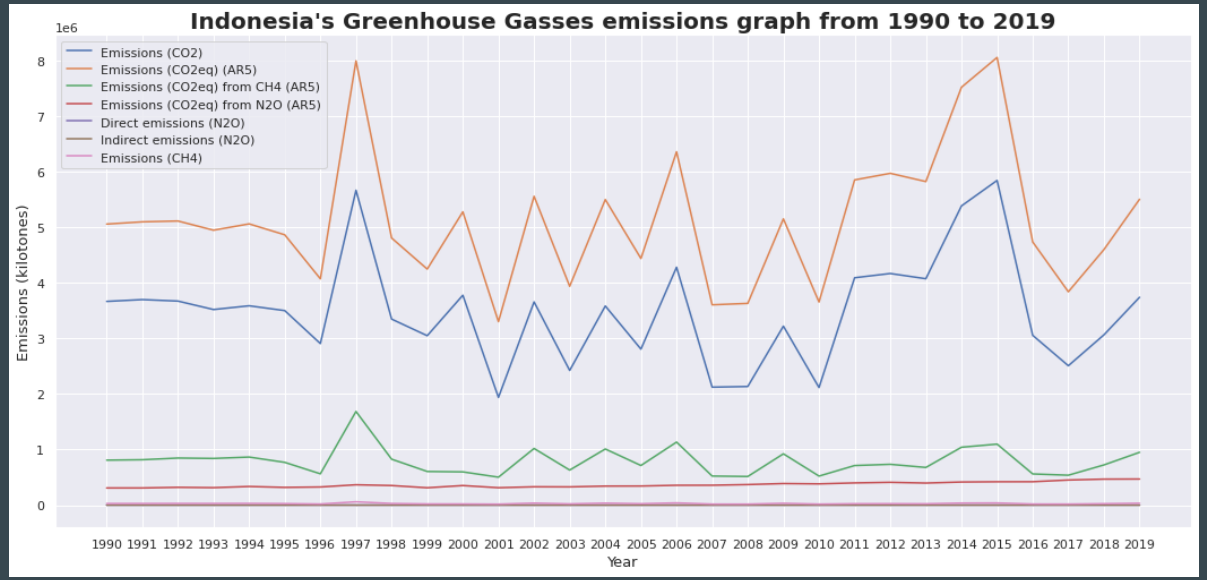


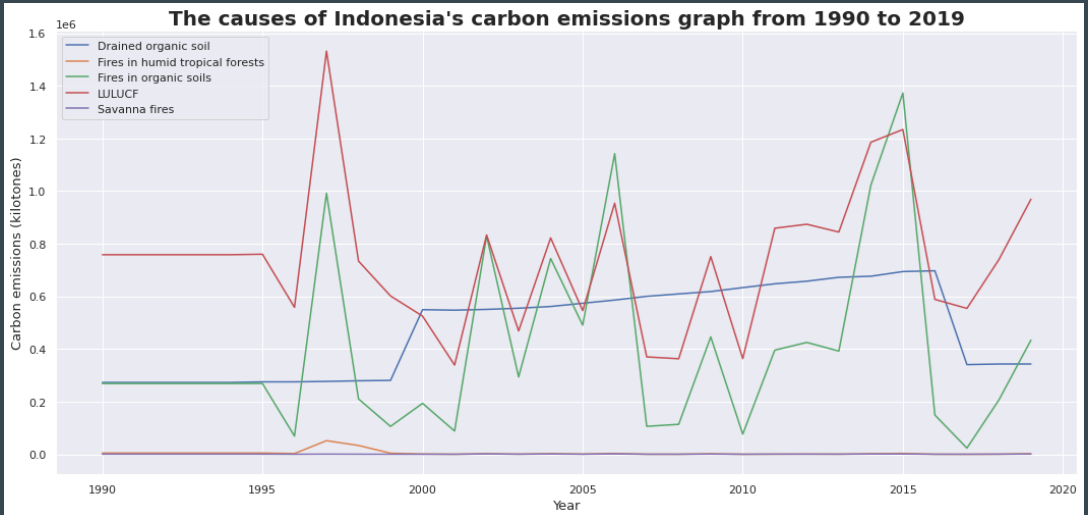
"From 2001 to 2020, Indonesia lost 27.7 Mha of tree cover, equivalent to a 17% decrease in tree cover since 2000, and 19 Gt of CO_2e emissions.."

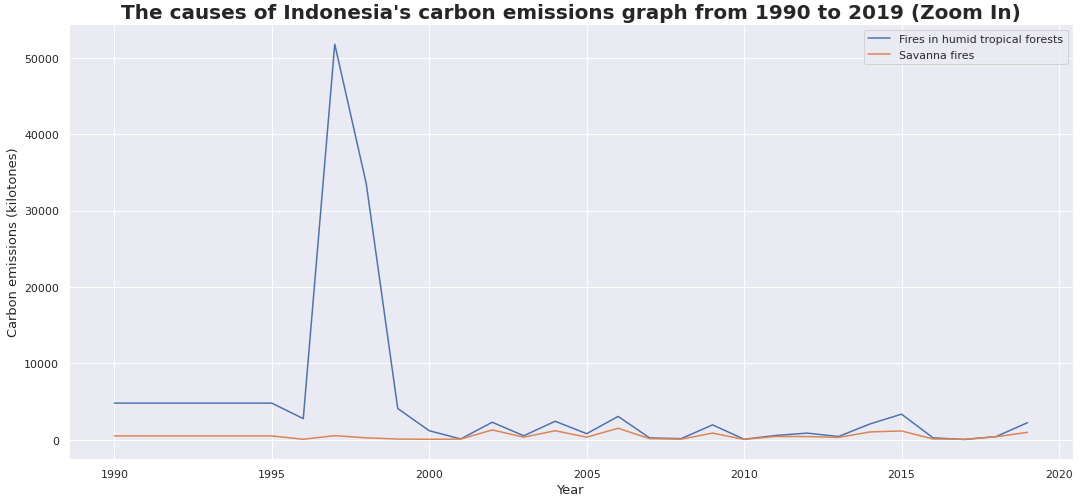
Source : Global Forest Watch

Indonesia Analysis

Based on IPCC AR5, Indonesia's carbon emissions fluctuate, which tends to have an **increasing trend** of around **3.5-8 Gigatonnes**, with the **highest peaks in 1997 and 2015**. From 1990-2019, the **total of Indonesia's carbon emission was around 96 Gigatonnes.**







- Based on the graph above, the most significant cause of carbon emissions from Indonesia is **LULUCF (Land Use, Land Use Change and Forestry)** which fluctuates around **800 Megatons,** with the **highest peak in 1997 of 1.6 Gigatonnes.**

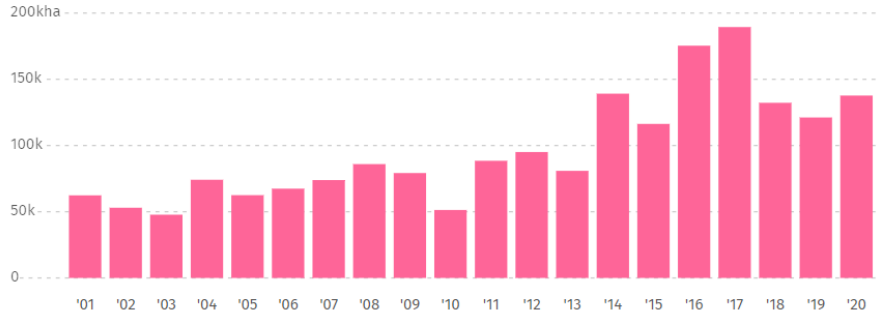
- Other causes of carbon emissions are caused by **the drying of organic soils** with an increasing trend, and the **burning of organic soils** fluctuates. In 2006 and 2015, the burning of organic soil even exceeded the LULUCF of 1.2 and 1.4 Gigatonnes.

05
India

The country with the tenth-largest forest area in the world.

According to **Global Forest Watch** :

- **In 2010,** India had 31.3Mha of natural forest, extending over 11% of its land area.
- **In 2020,** it lost 132kha of natural forest, equivalent to 67.3Mt of CO_2 emissions.

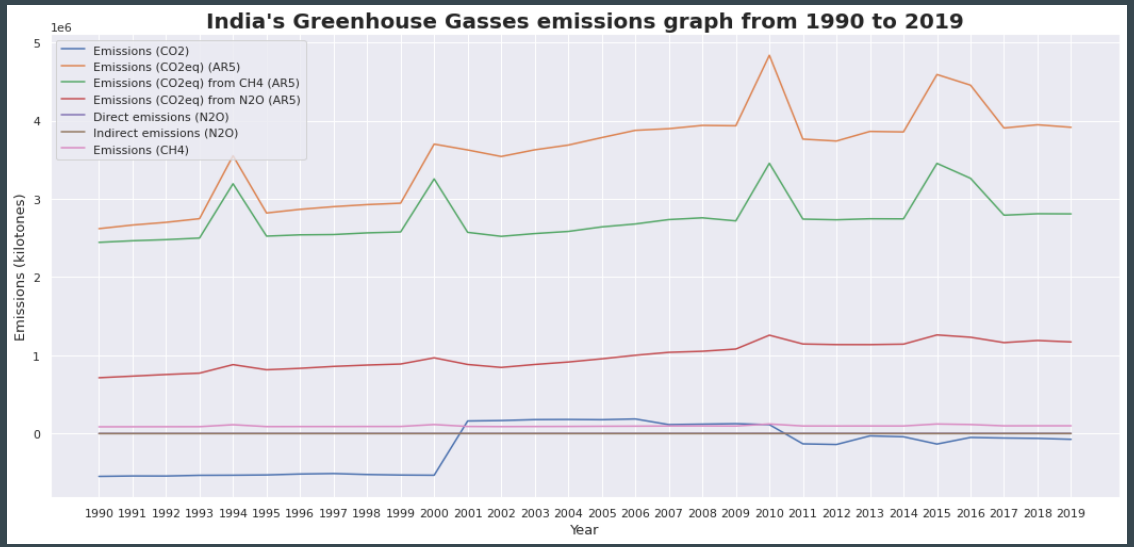


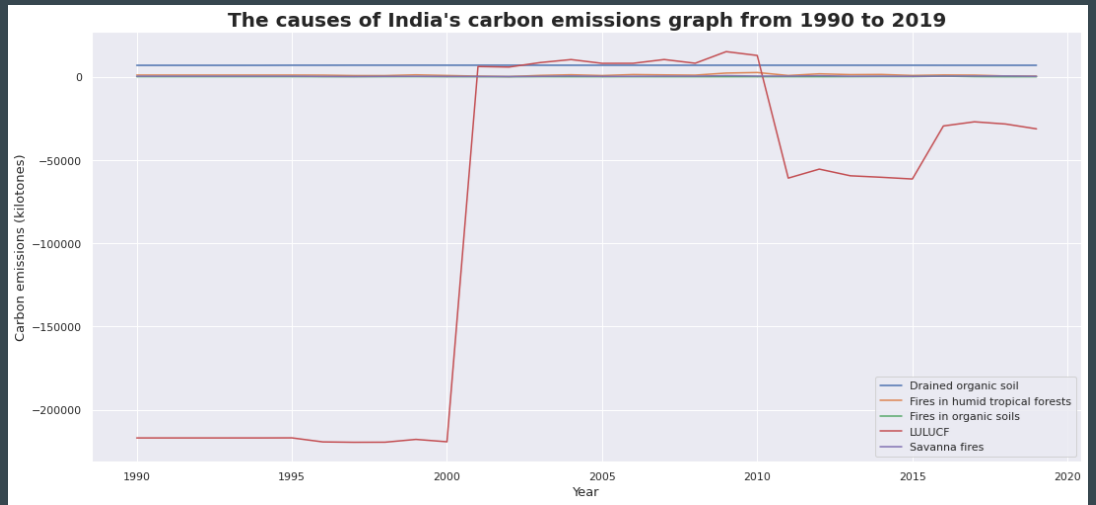
"From 2001 to 2020, India lost 1.93Mha of tree cover, equivalent to a 5.0% decrease in tree cover since 2000, and 951Mt of CO_2e emissions."

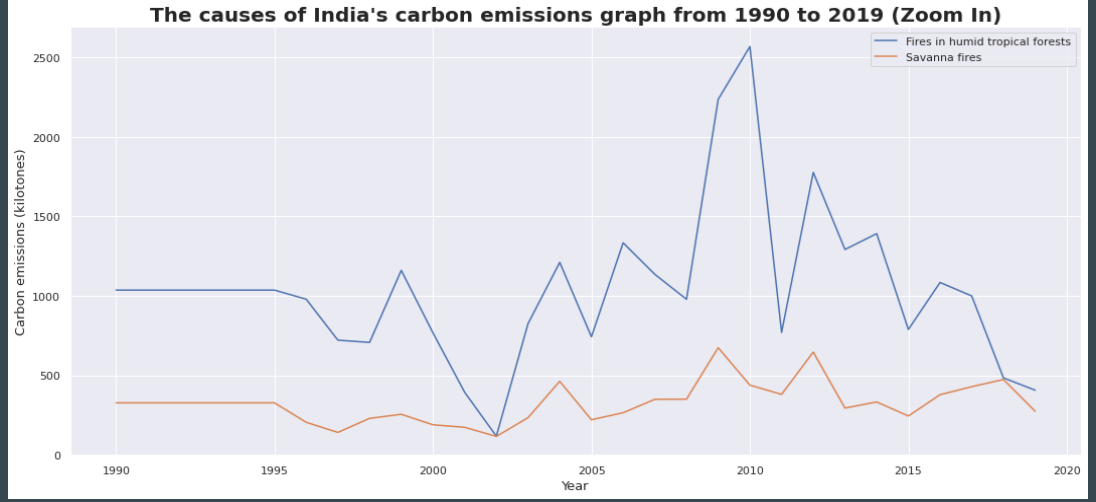
Source : Global Forest Watch

India Analysis

Based on IPCC According to IPCC AR5, India's carbon emissions tend to have an increasing trend, with several spikes in 1994, 2000, 2010, and 2015. Starting from 1990, India's total carbon emissions were around **2.5 Gigatonnes** until in 2019 it has increased in about 4 Gigatonnes.. From 1990-2019, the **total of India's carbon emission was around 74 Gigatonnes**.



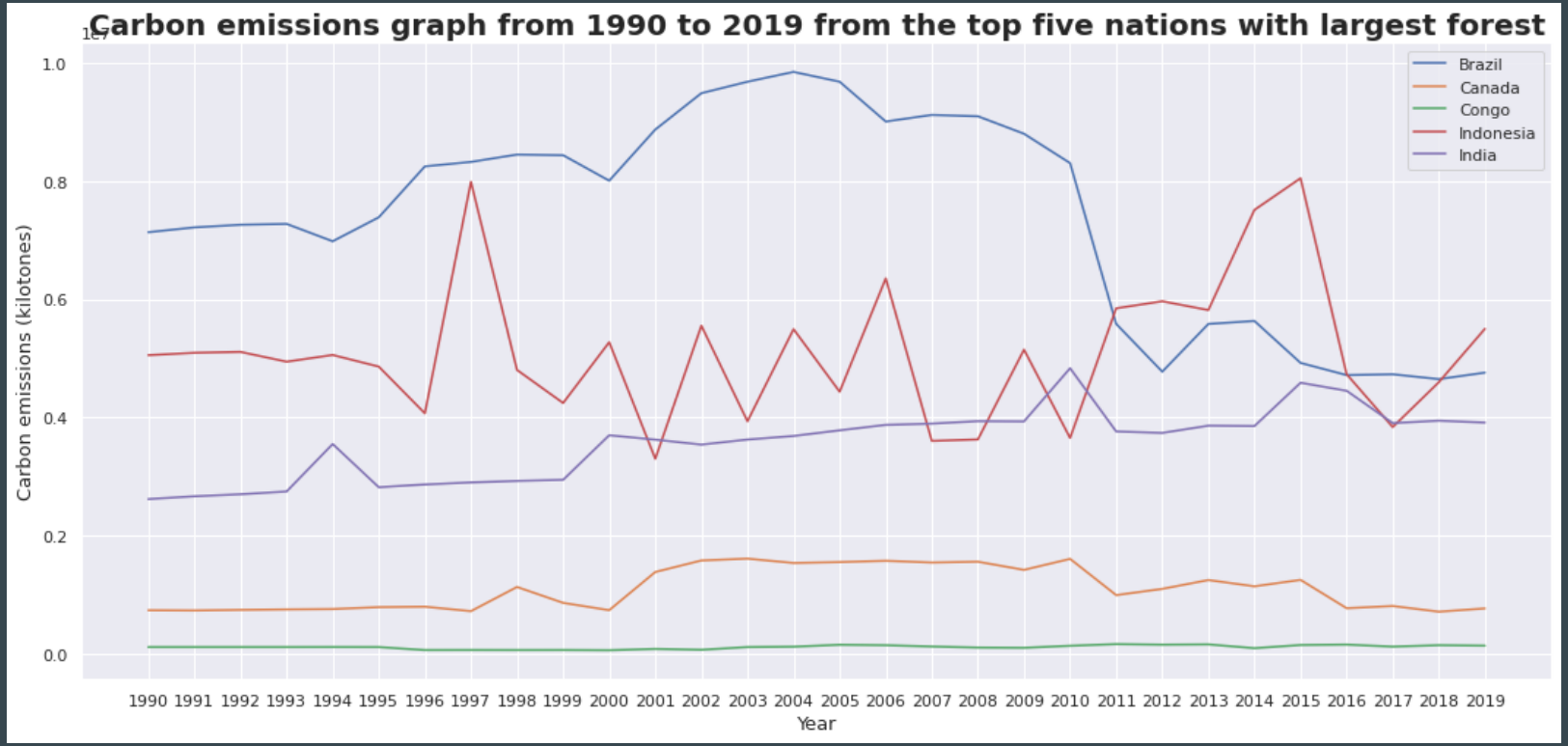




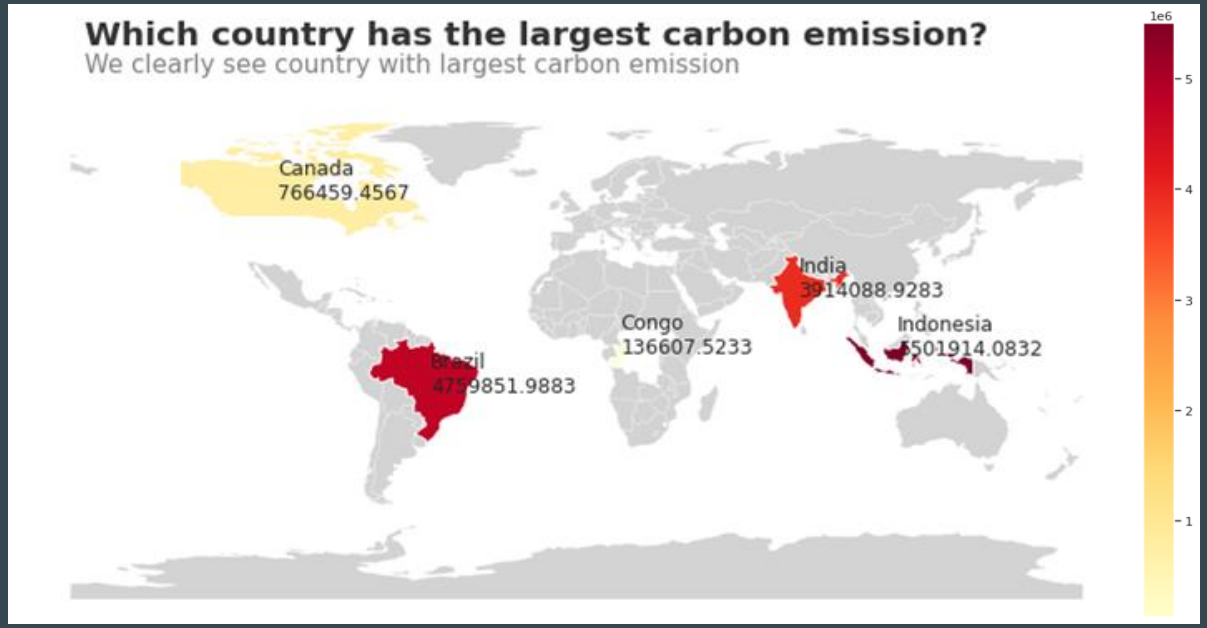
- Based on the graph beside, the biggest cause of carbon emissions from India is **LULUCF (Land Use, Land Use Change and Forestry)** which has a **minus value** in **1990-2000** and **2011-2019**, possibly caused by government programs to sequester carbon such as reforestation.

- Another cause of carbon emissions is **tropical forest and savanna fires**, which have a fluctuating graph. Tropical forest fires fluctuate around 0.5 to 1.5 Megatons with a peak, and savanna fires fluctuate at 0.5 Megatons.

Graph of Comparison



Carbon Emission in the Last 3 Years...



- Based on the graphic map above, in 2019 Indonesia was the country with the highest amount of carbon emissions compared to the five countries analyzed previously.
- Indonesia is a developing country with a tropical climate, which has the eighth largest forest area globally and is the fourth most populous country.
- The increase in land-use change due to industrial development and settlement expansion can cause the country's high carbon emissions.

Conclusion

Carbon Emission

Based on the number of carbon emissions in 2019, Indonesia has the highest number of carbon emissions of 5.5 Gigatonnes, while Brazil has the highest number of carbon emissions based on the cumulative carbon emissions from 1990-2019 of 137 Gigatonnes.

The Causes for Carbon Emission

LULUCF mostly dominates the Causes of carbon emissions; These can occur due to increased human activities that require land-use changes. The amount of carbon emissions increases due to deforestation of forest land into built-up land, while reforestation can reduce emissions by trees absorbing carbon from the atmosphere.

Reference

- FAO and UNEP. 2020. The State of the World's Forests 2020. Forests, biodiversity and people. Rome. [https://doi.org/10.4060/ca8642en]
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- Why are greenhouse gasses a problem? Accessed Online at 15 April 2022[https://www.inspirecleanenergy.com/]