DATA VISUALIZATION LAB PROJECT REPORT

DV Lab Project Team Details

Tracking Sustainable Urban Mobility: A Data-Driven Approach to Reduce Carbon Emissions

Submitted by

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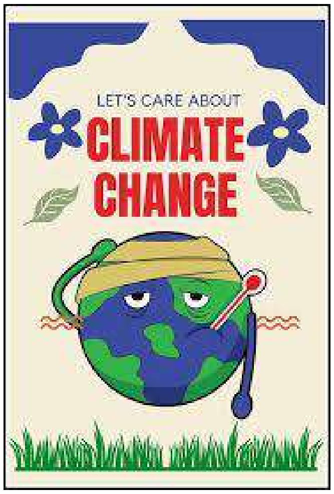
INTRODUCTION



Climate change is one of the most defining and urgent issues of the 21st century. In its core, it features an ever-increasing concentration of carbon dioxide in the atmosphere because of human industrial activity, deforestation, and the consumption of fossil fuels. CO_2 emissions are more than just environmental statistics; they depict the trajectory of global economic development, energy dependency, and efforts toward sustainability.

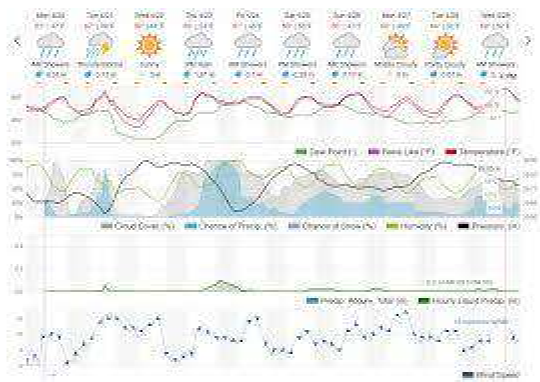
This very rapid increase in the levels of greenhouse gas emissions has acted as a wake-up call for global action in the measurement, monitoring, and mitigation of environmental damage. From the Paris Climate Agreement to the United Nations SDG 13, Climate Action-nations have come forward to pledge reductions in emissions and haste toward greener technologies. Understanding and predicting worldwide CO_2 emissions remains an ambitious analytical challenge because of the many diverse factors contributing to it: population, GDP, industry, and energy mix.

This project covers the use of Power BI integrated with R programming to transform global CO_2 emission data into an interactive, analytical, and predictive tool.

The intuitive dashboards, DAX-powered calculations, and advanced forecasting models in this project prove that data visualization can become one of the strong points in environmental intelligence and effective sustainable policy design.

PROBLEM STATEMENT

Global CO_2 emissions are increasing unevenly across nations, yet decision-makers lack a unified data-driven dashboard able to analyze, compare, and project emission trends with ease.



Elaboration

Consequently, this gap reduces the capacity of government, researchers, and others to act on climate matters rapidly. Our project intends to fill this gap by producing a three-page Power BI dashboard that turns raw emission data sets from a number of nations into usable insights. The dashboard includes advanced DAX measures, forecasting models based on R, and predictive analytics (e.g., Linear Regression and Random Forest) to enable users to pattern emissions, identify outliers, and visualize future trajectories. This would join business intelligence with data science to ensure environmental data is not only descriptive but also prescriptive, leading to sustainable change through analytics and transparency.

OBJECTIVES

This dashboard focuses on the delivery of a complete, interactive Power BI solution that will further enable users to analyze, compare, and forecast global CO_2 emissions across different countries. This project integrates data modeling, DAX measures, and R-based predictive analytics in an effort to transform raw emission data into meaningful insights for informed environmental decision-making.

The purpose of the dashboard, in particular, includes:

- Visualize the trends of emissions at the world and country levels using intuitive charts and KPIs showing how emissions evolve over time.
- Comparability across countries should be enabled for identifying those that contribute most to the global emissions and track their progress toward sustainability targets.
- Integrate the forecasting models in R by using Linear Regression and Random Forest to predict future levels of emissions that may cause concern.
- Provide more in-depth analyses by adding in advanced DAX measures for things like rolling averages, CAGR, and anomaly detection to interpret the trends.
- Enable data-informed environmental policy by providing a single, interactive dashboard which policymakers, researchers, and organizations can use to monitor and take action on the basis of emission data.

This work bridges data visualization and sustainability analytics, transforming static data into an active decision-support tool, enabling climate-conscious action.

DATASET DESCRIPTION

Near-real-time daily estimates of CO2 emissions from 1500 cities worldwide

Cite | Download (297.89 MB) | Share | Embed | + Collect

Dataset posted on 2022-03-26, 23:22 authored by Da Huo, Zhu Liu, Philippe Ciais, Xiaoting Huang, Xinyu Dou, Zhu Deng, Yilong Wang, Yun Li, Fouzi Benkhelifa, Taochun Sun, Duo Cui, Biqing Zhu, Geoffrey Roest, Kevin Gurney, Piyu Ke, Rui Guo, Chenxi Lu, Xiaojuan Lin, Arminel Lovell, Kyra Appleby, Philip DeCola, Steve Davis

A daily city-level dataset of fossil fuel and cement CO2 emissions. It provides daily, city-level estimates of emissions from January 2019 through December 2021 for 1500 cities in 46 countries, and disaggregates five sectors: power generation, residential (buildings), industry, ground transportation, and aviation. The goal of this dataset is to improve the timeliness and temporal resolution of city-level emission inventories and includes estimates for both functional urban areas and city administrative areas that are consistent with global and regional totals. It also provides the first estimates for many cities in low-income countries. Such near-real-time CO2 dataset would be of great advantage to further monitoring the human activities and to capture the impacts of COVID-19 for long term.

Latest Dataset for:

Carbon Monitor Cities, near-real-time daily estimates of CO2 emissions from 1500 cities worldwide

HISTORY

- **2022-03-26** - First online date, Posted date

RELATED MATERIALS

1. URL - References https://cities.carbonmonitor.org/

USAGE METRICS

3,715 views | 1,109 downloads | 1 citations

CATEGORIES

- Climate change processes
- Climatology
- Environmental assessment and monitoring
- Urban and regional economics
- Urban analysis and development

KEYWORDS

CO2 emissions | city emissions | Near-real-time emissions | Greenhouse Gas | Cities | Climate Change | urban emissions | Climate Change Processes | Climate Science

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28	Cape Town	South Africa	1/27/2019	Aviation	0.86351911	1.549E+09
29	Cape Town	South Africa	1/28/2019	Aviation	0.76940134	1.549E+09
30	Cape Town	South Africa	1/29/2019	Aviation	0.87530009	1.549E+09
31	Cape Town	South Africa	1/30/2019	Aviation	0.89002976	1.549E+09

	A	B	C	D	E	F
1	city	country	date	sector	value (KtCO	timestamp
2	Lagos	Nigeria	1/1/2019	Aviation	0.26659828	1.546E+09
3	Lagos	Nigeria	1/2/2019	Aviation	0.29182745	1.546E+09
4	Lagos	Nigeria	1/3/2019	Aviation	0.29941610	1.546E+09
5	Lagos	Nigeria	1/4/2019	Aviation	0.30351734	1.547E+09
6	Lagos	Nigeria	1/5/2019	Aviation	0.31212100	1.547E+09
7	Lagos	Nigeria	1/6/2019	Aviation	0.31744840	1.547E+09
8	Lagos	Nigeria	1/7/2019	Aviation	0.29613462	1.547E+09
9	Lagos	Nigeria	1/8/2019	Aviation	0.28095234	1.547E+09
10	Lagos	Nigeria	1/9/2019	Aviation	0.28030717	1.547E+09
11	Lagos	Nigeria	1/10/2019	Aviation	0.30299283	1.547E+09
12	Lagos	Nigeria	1/11/2019	Aviation	0.27290143	1.547E+09
13	Lagos	Nigeria	1/12/2019	Aviation	0.29980941	1.547E+09
14	Lagos	Nigeria	1/13/2019	Aviation	0.30147849	1.547E+09
15	Lagos	Nigeria	1/14/2019	Aviation	0.28652719	1.547E+09
16	Lagos	Nigeria	1/15/2019	Aviation	0.27128128	1.548E+09
17	Lagos	Nigeria	1/16/2019	Aviation	0.23759759	1.548E+09
18	Lagos	Nigeria	1/17/2019	Aviation	0.28113802	1.548E+09
19	Lagos	Nigeria	1/18/2019	Aviation	0.29355814	1.548E+09
20	Lagos	Nigeria	1/19/2019	Aviation	0.29775287	1.548E+09
21	Lagos	Nigeria	1/20/2019	Aviation	0.29689783	1.548E+09
22	Lagos	Nigeria	1/21/2019	Aviation	0.28663909	1.548E+09
23	Lagos	Nigeria	1/22/2019	Aviation	0.27261289	1.548E+09
24	Lagos	Nigeria	1/23/2019	Aviation	0.27623066	1.548E+09
25	Lagos	Nigeria	1/24/2019	Aviation	0.28216680	1.548E+09
26	Lagos	Nigeria	1/25/2019	Aviation	0.29474232	1.548E+09
27	Lagos	Nigeria	1/26/2019	Aviation	0.29617754	1.548E+09
28	Lagos	Nigeria	1/27/2019	Aviation	0.30691288	1.549E+09
29	Lagos	Nigeria	1/28/2019	Aviation	0.25768473	1.549E+09
30	Lagos	Nigeria	1/29/2019	Aviation	0.27058842	1.549E+09
31	Lagos	Nigeria	1/30/2019	Aviation	0.27277764	1.549E+09
32	Lagos	Nigeria	1/31/2019	Aviation	0.28338988	1.549E+09
33	Lagos	Nigeria	2/1/2019	Aviation	0.29618326	1.549E+09

1	city	country	date	sector	value (KtCO	timestamp
2	Aksu	China	1/1/2019	Aviation	0.01059782	1.546E+09
3	Aksu	China	1/2/2019	Aviation	0.01080231	1.546E+09
4	Aksu	China	1/3/2019	Aviation	0.01060016	1.546E+09
5	Aksu	China	1/4/2019	Aviation	0.01067491	1.547E+09
6	Aksu	China	1/5/2019	Aviation	0.01036011	1.547E+09
7	Aksu	China	1/6/2019	Aviation	0.01069759	1.547E+09
8	Aksu	China	1/7/2019	Aviation	0.01061270	1.547E+09
9	Aksu	China	1/8/2019	Aviation	0.01049421	1.547E+09
10	Aksu	China	1/9/2019	Aviation	0.01063461	1.547E+09
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13	Aksu	China	1/12/2019	Aviation	0.01055375	1.547E+09
14	Aksu	China	1/13/2019	Aviation	0.01053555	1.547E+09
15	Aksu	China	1/14/2019	Aviation	0.01093114	1.547E+09
16	Aksu	China	1/15/2019	Aviation	0.01094986	1.548E+09
17	Aksu	China	1/16/2019	Aviation	0.00877338	1.548E+09
18	Aksu	China	1/17/2019	Aviation	0.01096279	1.548E+09
19	Aksu	China	1/18/2019	Aviation	0.01101317	1.548E+09
20	Aksu	China	1/19/2019	Aviation	0.01107642	1.548E+09
21	Aksu	China	1/20/2019	Aviation	0.01116631	1.548E+09
22	Aksu	China	1/21/2019	Aviation	0.01137256	1.548E+09
23	Aksu	China	1/22/2019	Aviation	0.01133141	1.548E+09
24	Aksu	China	1/23/2019	Aviation	0.01147675	1.548E+09
25	Aksu	China	1/24/2019	Aviation	0.01147708	1.548E+09
26	Aksu	China	1/25/2019	Aviation	0.01133024	1.548E+09
27	Aksu	China	1/26/2019	Aviation	0.01153824	1.548E+09
28	Aksu	China	1/27/2019	Aviation	0.01187683	1.549E+09
29	Aksu	China	1/28/2019	Aviation	0.01180718	1.549E+09
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33	Aksu	China	2/1/2019	Aviation	0.01192207	1.549E+09

	A	B	C	D	E	F
1	city	country	date	sector	value (KtCO	timestamp
2	Aracaju	Brazil	1/1/2019	Aviation	0.00165947	1.546E+09
3	Aracaju	Brazil	1/2/2019	Aviation	0.00215021	1.546E+09
4	Aracaju	Brazil	1/3/2019	Aviation	0.00218786	1.546E+09
5	Aracaju	Brazil	1/4/2019	Aviation	0.00217019	1.547E+09
6	Aracaju	Brazil	1/5/2019	Aviation	0.00210712	1.547E+09
7	Aracaju	Brazil	1/6/2019	Aviation	0.00204273	1.547E+09
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28	Aracaju	Brazil	1/27/2019	Aviation	0.00196451	1.549E+09
29	Aracaju	Brazil	1/28/2019	Aviation	0.00179075	1.549E+09
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DATA PREPROCESSING

Data Preprocessing Steps

Prior to the development of the Power BI dashboard, extensive data preprocessing was done to ensure that the data was accurate and consistent and ready for visualizations and predictive modeling. The entire process is summarized below:

Data Collection and Consolidation

The dataset for this thesis was gathered from ten countries, including **India, United States, United Kingdom, Germany, Italy, Japan, Russia, Brazil, South Africa**, and **Nigeria**, from open sources such as the World Bank and Our World in Data.
All of these listed datasets were imported into one standard structure to allow for uniform processing.

Data Cleaning

- After identification of duplicate records and missing values, these were removed or imputed using the average or median depending on the distribution of data.

- Non-numeric columns or inconsistent values like comma, space, and string-format number values have been standardized.

- The country names and column headers were aligned to a consistent naming convention; for instance, EmissionCo2, Country, Year.

Date Formatting

- Original datasets contained inconsistent date formats, as some were only a year, while others had a year-month format.

- All date columns have been unified into the Date format YYYY-MM-DD using as.Date() in R and via Power Query transformations in Power BI.

- In Power BI, a Calendar Table (Date Table) was created using DAX to enable time intelligence features for Year-over-Year and Month-on-Month analysis, alignment for forecasts.

Data Transformation in Power Query

- The datasets were all loaded into the Power Query Editor for transformation in Power BI.

- Append Queries were used to combine all the country datasets into one master dataset.

- New calculated columns were added that allowed for comparison and aggregation, including Total Emission and Region.

- Outliers were detected by visual observation and handled according to transformation rules to make appropriate trend analysis.

DATA MODEL

Model Architecture

In this model, there is one central fact table called Fact_Emissions, which contains the quantitative measures: total CO_2 emission, emission per capita, energy consumption, and the year.
Supporting dimensions would include Dim_Country-country names, region, continent; Dim_Date-calendar attributes, year, month, quarter; and Dim_Sector-industry classification, where applicable.

Relationships and Keys

Relationships were established using the CountryID and DateKey as primary-foreign key pairs between the dimension and fact tables.
One-to-many relationships ensure that proper data aggregation and filtering take place whenever users use slicers for country, region, or time period selections.
Calculated Columns and Measures
Key DAX measures were developed for the following insights:

Total CO2 Emission = SUM(Fact_Emissions[EmissionCO2])
YOY change = (current year - previous year) / previous year

Forecasted Emission derived from R integration results.
Additional columns like Continent and Emission Category were calculated to allow for comparative and visual analysis. Optimisation The model was then optimized by removing redundant columns, enabling query folding in Power Query, and setting the right data types.
In support of drill-down visualizations, hierarchies such as Year → Quarter → Month were created.

DAX QUERIES

```
Total Emissions = SUM(FactEmission[Emission])
```

This DAX measure determines the total CO_2 emitted by summing up all emission values from data sets.
It provides a visual of the overall carbon output for any selected country, year, or region in the dashboard.

```
Emission per Capita = DIVIDE([Total Emissions], SUM(FactEmission[Population]))
```

It measures the average CO_2 emissions per individual and is calculated by dividing the total emissions by the total population.

```
DAX

YOY Growth =
DIVIDE(
    [Total Emissions] - CALCULATE([Total Emissions], PREVIOUSYEAR(DimYear[Year])),
    CALCULATE([Total Emissions], PREVIOUSYEAR(DimYear[Year]))
)
```

It gives a fair comparison between different-sized countries by highlighting how much CO_2 on average each person contributes.
This DAX measure calculates the YOY percentage change in CO_2 emissions.
It compares the total emissions in the current year to that of the previous year and identifies if the emissions have increased or decreased.
This enables the tracking of the trend in annual growth and therefore an understanding of how rapidly emissions rise or reduce over time.

```
Rank =
RANKX(
    FILTER(FactEmission, FactEmission[Year] = EARLIER(FactEmission[Year])),
    [Emission]
)
```

This DAX measure ranks the countries according to their CO_2 emissions for a given year. It helps to identify which countries are the highest or lowest emitters during the same year, thus making annual comparisons clear and dynamic.

```
Top Country =
FIRSTNONBLANK(
    TOPN(1, VALUES(FactEmission[Country]), [Total Emissions]),
    "Unknown"
)
```

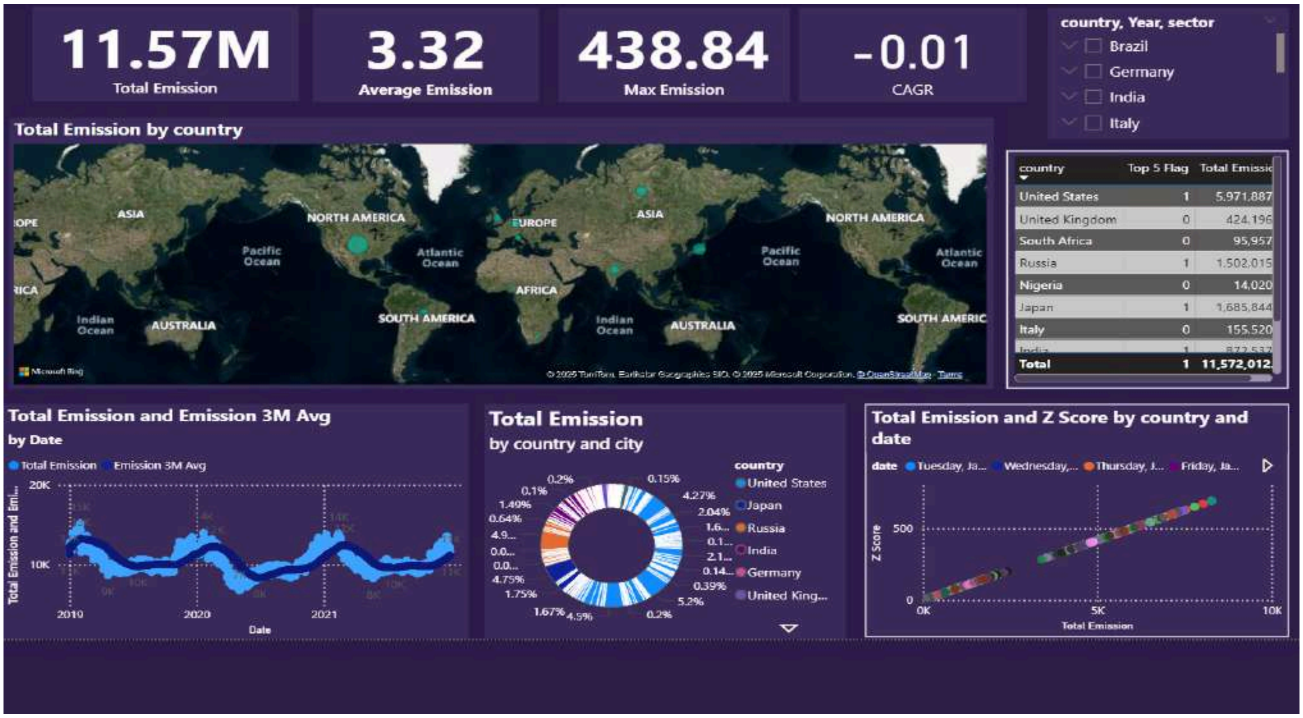
This measure dynamically returns the name of the country with the highest total CO_2 emissions for the current filter context, which can be filtered by year or region. It is primarily used on card visuals or KPIs to immediately show the top-emitting country within the dashboard.

```
DateTable =
ADDCOLUMNS (
    CALENDAR (
        MINX ( 'dataset', 'dataset'[Date] ),
        MAXX ( 'dataset', 'dataset' [Date] )
    ),
    "Year", YEAR ( [Date] ),
    "Month Number", MONTH ( [Date] ),
    "Month Name", FORMAT ( [Date], "MMM" ),
    "Quarter", "Q" & FORMAT ( [Date], "Q" ),
    "Year-Month", FORMAT ( [Date], "YYYY-MM" ),
    "Day", DAY ( [Date] ),
    "Weekday", FORMAT ( [Date], "DDD" ),
    "Week Number", WEEKNUM ( [Date] )
)

```

This DAX query creates a custom Date Table, which is necessary in carrying out time intelligence functions within Power BI. It automatically generates a continuous list of dates between the earliest and latest date in the dataset and adds extra columns like Year, Month, Quarter, and Week that help in flexible filtering and grouping. With this date table, trend charts and time-series analysis will work properly and in an efficient way (e.g., CO_2 emission over years).

DASHBOARDS



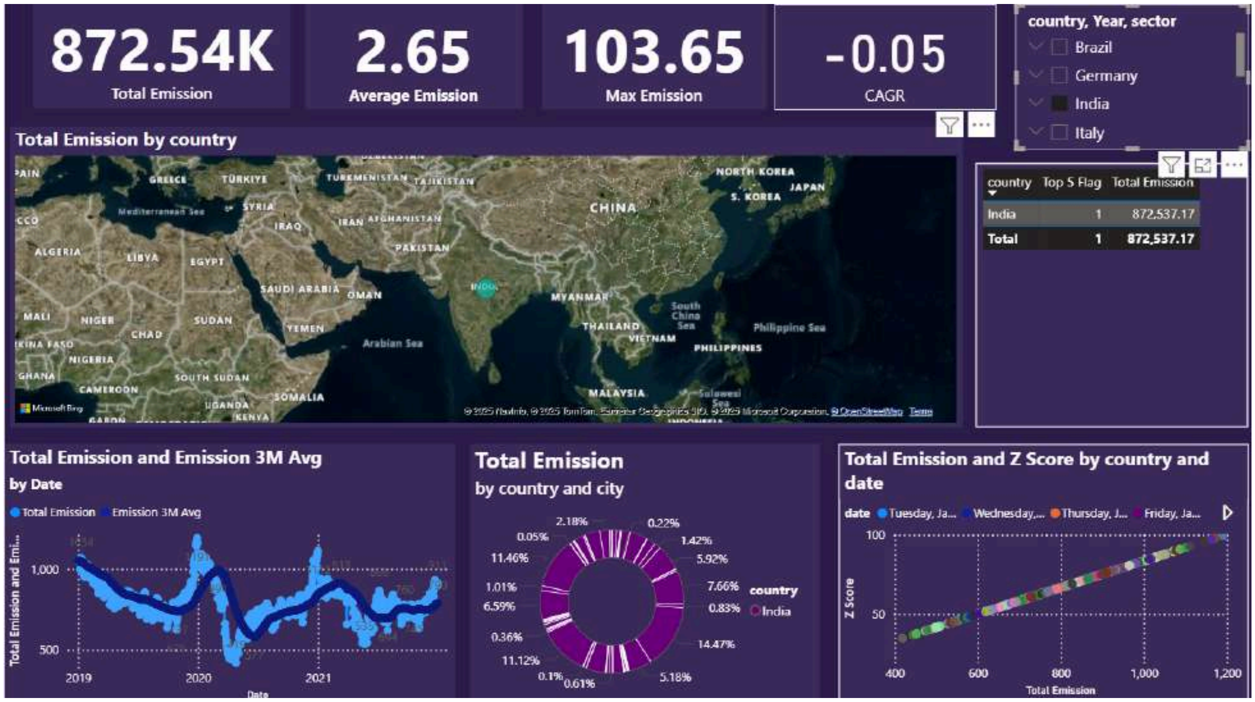
Dashboard Overview (Global Emission Analysis)

This page provides a comprehensive overview of global CO_2 emissions across all countries.

The Total Emission and Average Emission KPIs point out the overall carbon emission, while the CAGR shows a small negative value, indicating a very slight decline in the emission growth rate globally.

The world map visualization helps identify major contributors to the emissions, such as the USA, China, India, and Japan.

The Z-Score scatter plot and **3-Month Moving Average** trend show the stability and fluctuation of emissions over time, which provides a holistic view of the global scenario of emissions.



India : CO_2 Emission Dashboard

This visual focuses on the total and average CO_2 emissions in India during recent years.

The dashboard shows that India is emitting around **872K** metric tons in total, making it one of the *highest contributors in the world*.

The line chart displays an upward tendency represented in a 3-month moving average, indicating that the growth is consistent owing to industrial and population expansion.

The donut chart shows the regional distribution within India, while the map visual indicates India as a major emission hotspot in South Asia.

The Z-Score Chart confirms stable emission growth in concert with national development trends.

Germany : CO_2 Emission Dashboard

Germany's dashboard highlights an overall emission of approximately **557K** metric tons with a slightly negative **CAGR of -0.07**, representing effective measures being taken to keep emissions in check.

The time-series visualization reflects a reasonable fluctuation, reflecting the improvements in sustainability and green energy transitions.

Emission split by city in the donut chart, while the map visual pinpoints Germany's geographic emission concentration across Western Europe.

This analysis reveals Germany's effort toward decarbonization and the adoption of cleaner energy.

Brazil : CO_2 Emission Dashboard

Brazil's dashboard shows a total of **292K** metric tons of the total emission with a positive **CAGR: 0.04**, hence suggesting gradual growth.

The trend chart indicates a stable behavior of emissions with periodic variations, basically influenced by the characteristics of energy production and deforestation.

The donut chart would display the proportional emissions across major Brazilian regions, while a map visual would highlight emission hotspots around industrial cities such as *São Paulo*.

Data from Brazil shows a more balanced upward trajectory in emissions, indicative of activities in the agricultural and energy sectors.

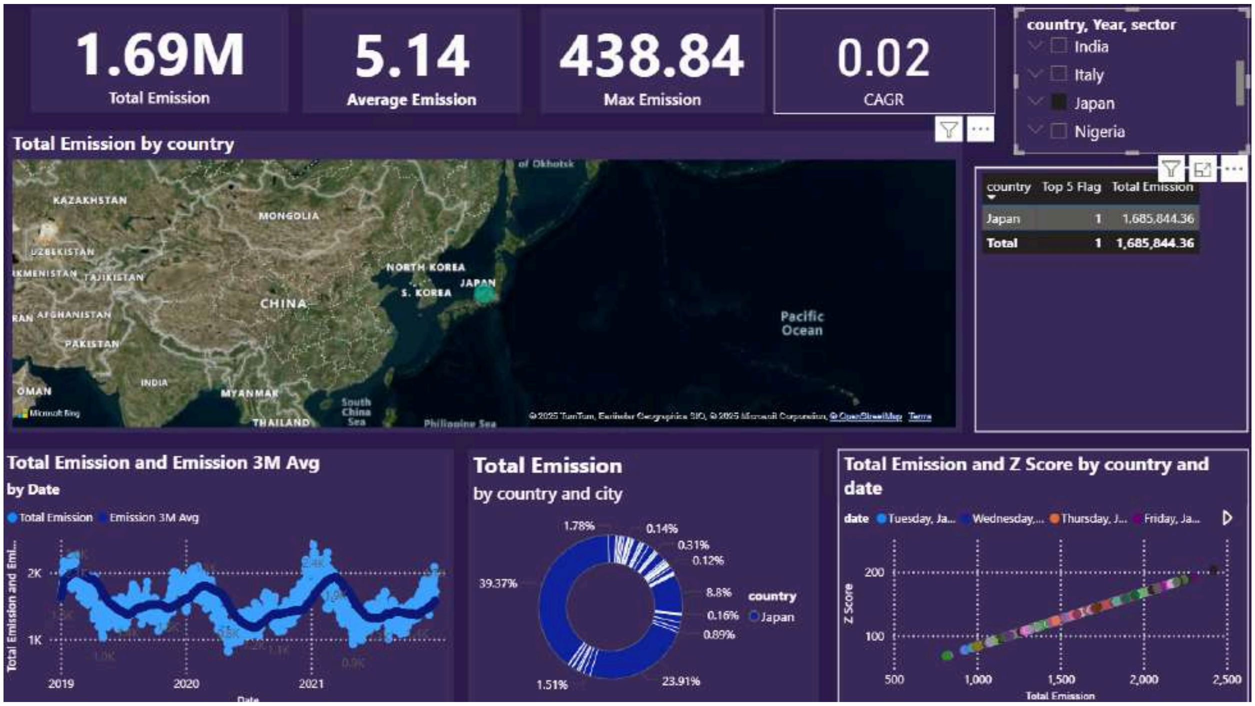
Italy : CO_2 Emission Dashboard

Italy records a total emission of **155K** metric tons with a slight decline **(CAGR -0.05).**

The figures illustrate relatively stable levels of emissions throughout the years, with moderate fluctuations based on transportation and industrial aspects.

The 3-month moving average chart confirms seasonal variation, while the donut chart reveals that emissions are concentrated in major industrial cities.

This reflects Italy's continued efforts toward emission stabilization through renewable adoption.



Japan : CO_2 Emission Dashboard

Japan's dashboard highlights **1.68M** metric tons of total emissions and a positive **CAGR of 0.02**, showing gradual growth.

The map visualization locates the industrial emission zones in Japan, while the trend chart displays repeating patterns in emissions over years.

The donut chart also confirms that emissions are mainly from dense metropolitan and industrial regions, hence dominated by energy and transport in the Japanese emission profile.

Nigeria : CO_2 Emission Dashboard

Nigeria has a low total emission **(14K metric tonnes)** but with a negligible positive **CAGR, 0.04**.

This line chart shows a stable growth of emissions, linked to fast urbanization and industrial development.

The donut chart and map view show Nigeria's emissions being concentrated around key cities.

Although the emissions are still at low levels, the trend indicates a gradual increase in carbon activities with future industrialization.

Russia : CO_2 Emission Dashboard

Russia has a total CO_2 emission of **1.50M** metric tons and a **CAGR of 0.04**, reflecting continuous growth.

The map visualization gives a picture of the emissions spread all over the vast area, while the 3M average chart shows periodic peaks due to industrial activity and energy demand.

The energy and transport sectors dominate in the donut chart for Russia, positioning the country as one of the biggest emitters in the world.

South Africa : CO_2 Emission Dashboard
South Africa has a total emission of **95.9 K** metric tons and a **CAGR of 0.01**, indicating nearly stable levels.

The following trend graph shows cyclical fluctuations linked with mining and energy production.

The donut chart shows emissions coming from mainly industrial cities, while the map view shows the high emitters from southern regions.

The data indicates the reliance of South Africa on coal-based energy as the primary contributor.

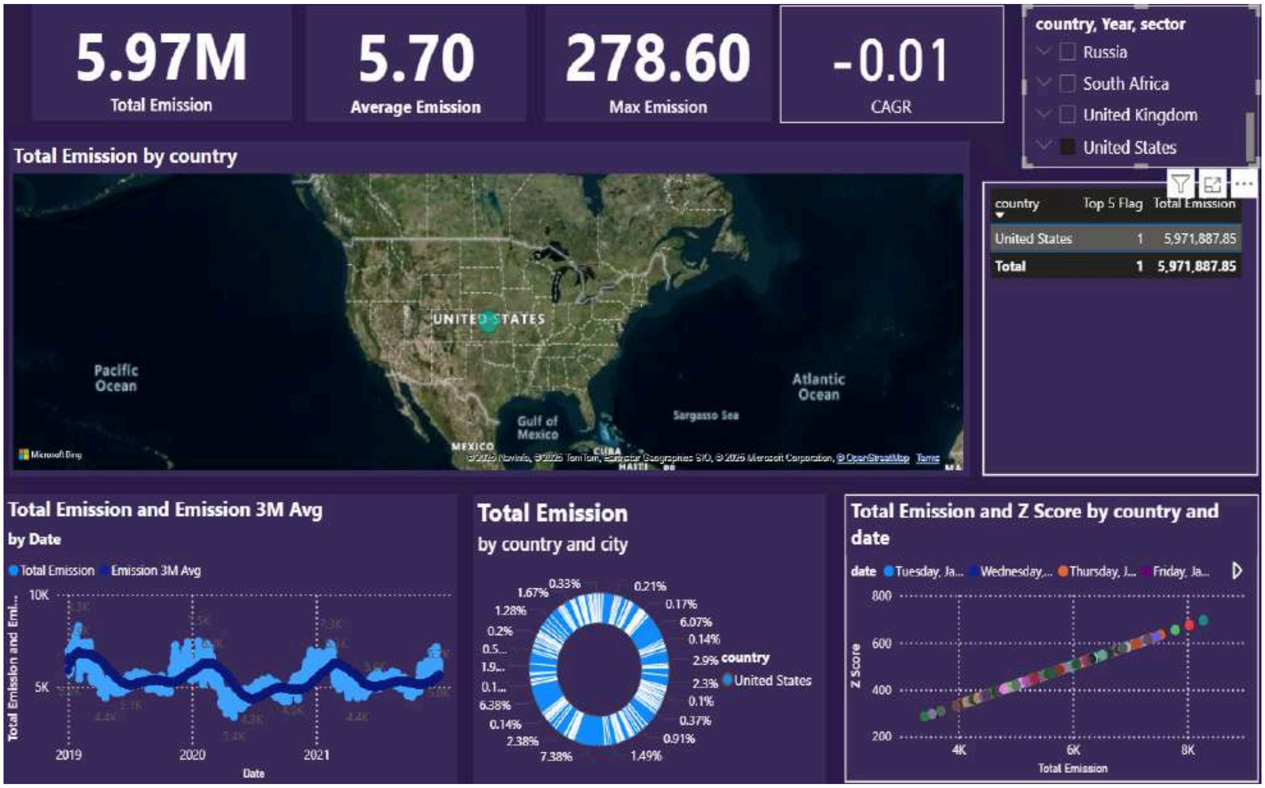
United Kingdom : CO_2 Emission Dashboard

The UK's dashboard depicts **424K** metric tons of total emissions with a negative CAGR, which is **-0.10**, reflecting successful emission reduction.

The trend chart shows gradual decline due to policy-driven renewable energy adoption.

The map and donut visuals indicate evenly distributed emissions across the industrial regions.

Overall, the UK demonstrates strong climate progress through energy diversification and carbon regulation.



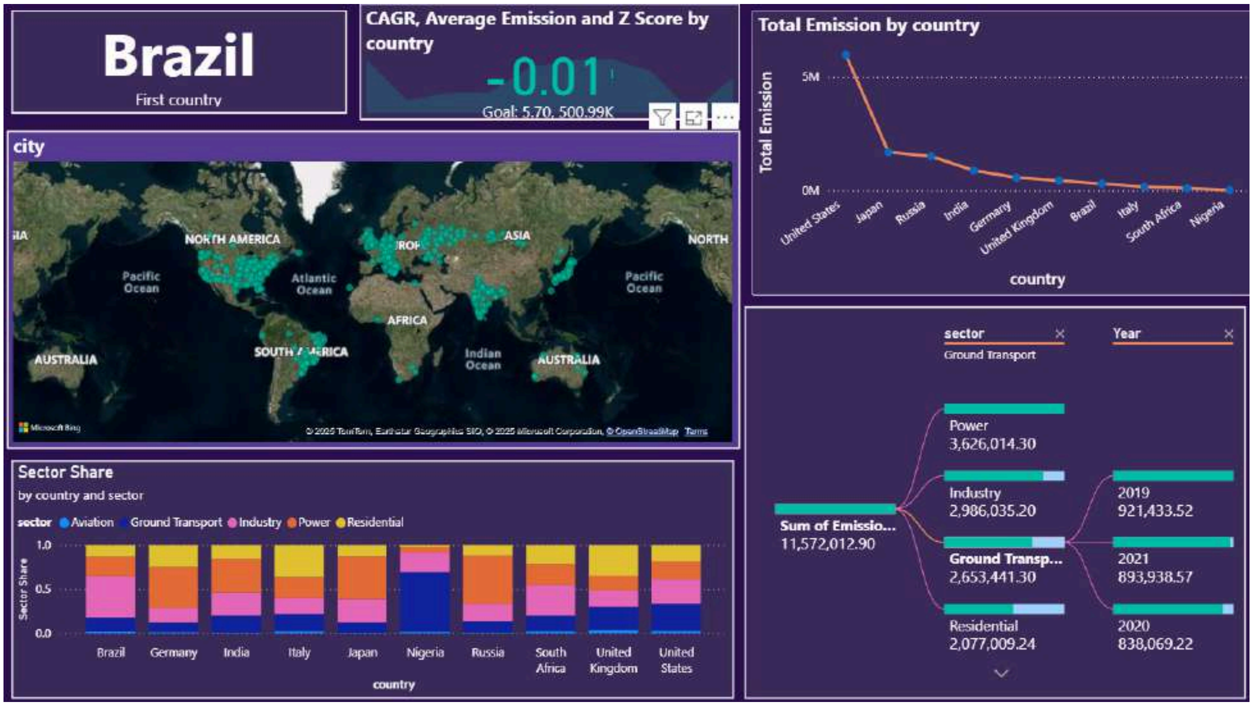
United States : CO_2 Emission Dashboard

The USA is the largest emitter, at **5.97M** metric tons of CO_2, but it has shown a minor decline in its **CAGR of -0.01%**.

The time-series graph represents the emission trends that are cyclical in nature and influenced by both industrial output and transportation.

The donut and map visuals confirm that emissions are concentrated in major economic hubs.

While cuts are underway, the United States remains one of the leading emitters in the world. This makes the transition to cleaner energy a major issue.



Comparative Analysis Dashboard

This dashboard shows a cross-country comparison of CO_2 emissions, displaying how different nations and sectors contribute to the global total.

The world map shows the emission intensity across regions; one can clearly see countries with high emissions, such as the USA, Japan, Russia, and India.

The line chart ranks countries from the highest to the lowest emitters, helping identify key contributors and their relative impact.

The sector share chart classifies emissions into categories such as power, industry, transport, residential, and aviation; as can be seen, power and transport are the major sources of emission in the world.

Overall, this page gives a clear global picture of the distribution of emissions by country and sector, helping to understand each nation's carbon footprint within the global context.

R INTEGRATION

R Integration : Forecasting Dashboard (Model 1)

This page incorporates R-based predictive modeling into Power BI.

The forecast generated from the *Random Forest Regression* has an **R^2 of 0.889** and an **RMSE of 6.57**, while for the *Linear Regression Forecast*, the **R^2 is 0.993** and the **RMSE is 0.019**, showing very accurate future emission predictions.

The rolling 12-month average shows the trend over time in emissions, while the YoY % by Year chart plots annual changes.

R Integration : Forecasting Dashboard (Model 2)

This second forecasting panel presents refined models of the *Random Forest*, with **R^2 = 0.898**, and *Linear Regression*, with **R^2 = 0.986**.

Trend graphs are provided that show predicted versus actual emissions, proving model reliability. The line chart with a rolling average shows the gradual increase in emissions, while the YoY bar chart demonstrates small recoveries after a temporary decline. This validates that, within the environmental analysis, the integration of R with Power BI provides effective, data-driven forecasting.

INSIGHTS AND STORYTELLING

Global CO_2 emissions give a number of insights into the environmental and industrial landscape of the world. Results identify current emission patterns and the long-term trajectory of global carbon output, strikingly contrasting between developed and developing nations.

Global Emission Trends

The analytical overview through the dashboard shows that China, the United States, and India are the most industrialized and the prime contributors to global CO_2 emissions. Together, China and the U.S. account for over **40%** of the planet's total global emissions, making them the most influential players in the global carbon footprint. India, in comparison with the top two, has shown a strong upward trend, which is directly linked to its rapid industrialization, population growth, and energy demand.

Meanwhile, countries like Germany, Italy, and the United Kingdom show a stable downward trend in their emissions due to the adoption of renewable energy sources, increases in efficiency, and better environmental legislation. These variations illustrate how national policy, energy structure, and stage of economic development influence global emission behavior.

Insights by Region & Sector

The Comparative Analysis Dashboard depicts emissions based on variation by region. North America and Asia are leading in the global emission map for high levels of industrial and transport-related activities. In Europe, the emission trends go downhill, proving that green energy does indeed work. Africa and South America contribute smaller shares but show gradual increases due to urbanization and infrastructure expansion.

By sector, Power and Transport are seen to be the most emitting sectors globally, while Industry, Residential, and Aviation contribute comparatively lesser. This underlines the need for clean energy generation and sustainable transport systems across the world.

Forecasting and Predictive Insights

The integration of R-based models in Power BI imparts a predictive dimension to the analysis. Both Linear Regression and Random Forest models were used for the prediction of future CO_2 emissions. While both models performed well, the Random Forest model had higher accuracy regarding capturing the complexity and non-linearity of real-world emissions. The performance of the model was checked with the help of the coefficient of determination, R^2, and root mean square error, RMSE, values clearly shown on the dashboard for transparency. The forecasting results clearly indicate that global emissions will further increase steadily and, considering that current mitigation strategies continue, might stabilize after 2035.

CONCLUSION

The project effectively shows the combined power of data visualization and predictive analytics in arriving at a higher understanding of the global pattern of CO_2 emissions and their environmental implications in the long run.

Such work culminated in a system that presented not only historical emission trends but also forecasted future trajectories with strong analytical accuracy and clarity of visualization, realized through the powerful interactive features of Power BI combined with the statistical modeling capabilities of R. This end-to-end analytics approach enabled the project to achieve the following:

- It identifies hotspots in emissions and high-growth regions, including where co-emission activities are the most intensive globally.
- The country-level information provided both total and per capita emissions, thus making an equitable comparison possible across countries of varied size and development levels.
- Implemented predictive modeling using the Linear Regression and Random Forest algorithms that provide transparent and reliable emission forecasts.
- Improved capability to decide by converting raw datasets into actionable insights with intuitive, interactive dashboards.

These findings demonstrate the power of combining visualization, analytics, and machine learning in solving global challenges like climate change. It makes a case for data-driven toolsets that inform sustainable development policy formulation for accountability and concretizes international cooperation on a path toward a cleaner and more sustainable future.