Faculty Of Computing Informatics

Data Visualisation (CDS6324)

Trimester 2, 2023/2024

The Global Carbon Footprint

(Group 4)

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Task Division

Name	Tasks Done
Ayat Abdulaziz Gaber Al-Khulaqi	Data Analysis: - Share of Global CO2 Emissions - Share of Global CO2 Emissions and Income - CO2 Emissions in Different Industries - Maps - Dashboards (1 to 4) - Data Story Report: - Dataset Description - Pattern discovery - Report layout - Video
Roha Ali	Data Analysis: - Global CO2 Emissions - Cumulative CO2 Emissions in Different Industries - Cumulative CO2 Emissions by Continents - CO2 Types against Country Economic status Report: - Introduction. - Dataset Description. - Pattern discovery.
David Lim Yang Kai	Data Pre-processing: - Missing Values - Data Formatting Data Analysis: - CO2 Emissions and Population Throughout the Decades - Comparison of Greenhouse Gasses to Temperature Change - Temperature Change of the World throughout the Decades - Temperature Change of the World - Greenhouse Gasses Percentage on Temperature Change Report: - Data Pre-processing - Conclusion - Pattern Discovery

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1. Introduction

Ignited primarily by the combustion of fossil fuels, changes in land use, and economic landscapes, a stark shift in temperature and worldwide climate has been noticed over time. From increasingly harsh summers to frequent flooding and storms, the climate is beginning to change. According to the Intergovernmental Panel on Climate Change (IPCC)'s report in 2022 harmful carbon emissions from 2010-2019 reached unprecedented levels in human history underscoring that it is "now or never" to limit the emissions and subsequent climate change to prevent natural disasters such as major cities being submerged, unprecedented heatwaves, storms, water shortages, and the extinction of flora and fauna.

With these staggering figures in mind, this study aims to understand the historical emergence and contributing factors of carbon dioxide as well as the economic and climatic ramifications of these emissions. The study uses a dataset from 1750-2021, containing data on CO2 emissions, country data, economic indicators, and industrial and regional contributions.

Through detailed analysis and visual representations, the study aims to understand important trends and relationships that underscore the urgency of addressing global CO2 emissions and their impact on the Earth's temperature.

2. About the Dataset

This research implements a carbon dioxide (CO2) emissions dataset from 1750 to 2021, presenting sectoral emissions such as cement, coal, oil, gas, flaring, and land use change. The dataset contains demographic and economic indicators for the referenced nations/regions, population, and GDP indexed with respect to the international dollar ($) at 2011 rates. It also has the category and data for countries by income brackets and their continents. Moreover, it monitors the global emissions by country, among other aspects about each country's carbon dioxide emissions. The comprehensive analysis of how each country's GDP, industry pollutants, temperature increase, and accumulation of C02 affect the global climate can be carried out using this data set.

3. Data Pre-Processing

The data pre-processing stage aimed to ensure the quality and consistency of the data for further analysis. This involved the following steps:

a. **Missing Values:** We checked for missing values in the visualizing_global_co2_data.csv and other relevant variables. There was surprisingly a lot of consistently missing data from the year 1750s to 1950s and the year 2021 to 2022. Due to this we opted to remove the data from those years and have decided to use data starting from the year 1989 to 2019 to achieve a more consistent data. However, exceptions are given to both *Figure 4.3* and *Figure 4.10* as the data provided is sufficient and accurate.
b. **Data Formatting:** The data of “Country” underwent some reformatting due to inconsistent naming as well as inaccuracies of some regions of the world. Not only that, it also included duplicate countries causing influx of data. Hence, we have manually grouped the appropriate countries into their respective regions (Americas, Asia, Europe, Africa, Oceania), doing so was able to ease our data visualizations.

By implementing these pre-processing steps, we ensured a clean and reliable dataset for further analysis of CO2 emissions and related factors.

4. Pattern discovery

The Rise of CO2

The distribution of carbon dioxide emissions across nations for year 2021 is shown on *Figure 4.1*. Emission levels are shown using varying colours with a key. Light Gray stands for areas with the least emissions, while dark red signifies high quantities of carbon dioxide in the area. China is highlighted in dark red, indicating it has the highest emissions, followed by the United States, shaded in a lighter red. Conversely, South America, Africa, and Australia are shown in shades of Gray, signifying lower emissions levels. This visualization underscores the significant disparities in CO2 emissions between countries, with major contributors predominantly located in Asia and North America.

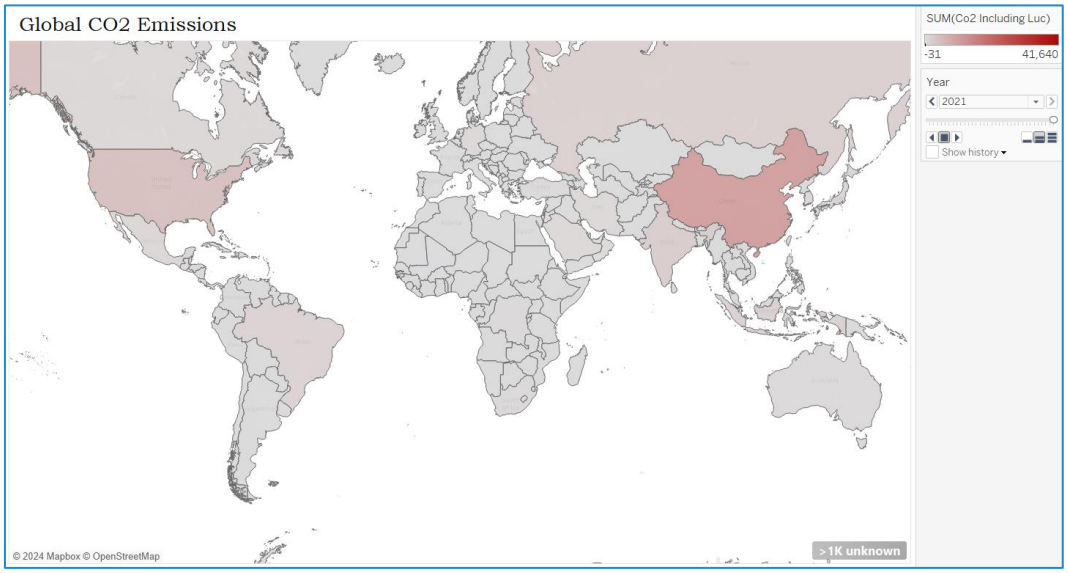

Figure 4.1 Global CO2 Emissions

The distribution of carbon dioxide emissions among different industrial sectors can be seen in Figure 4.2. The segments of the graphic represent Cement, Coal, Flaring, Gas, Land Use Change, and Oil. Coal is the biggest source of carbon dioxide emissions, followed by Oil, Gas and Land Use Change sectors. Emissions from Cement and Flaring are less significant. Based on this graphical representation, one can deduce that the greater share of the world's carbon dioxide emission comes from industries that use fossil fuels which mainly consist of coal and oil.

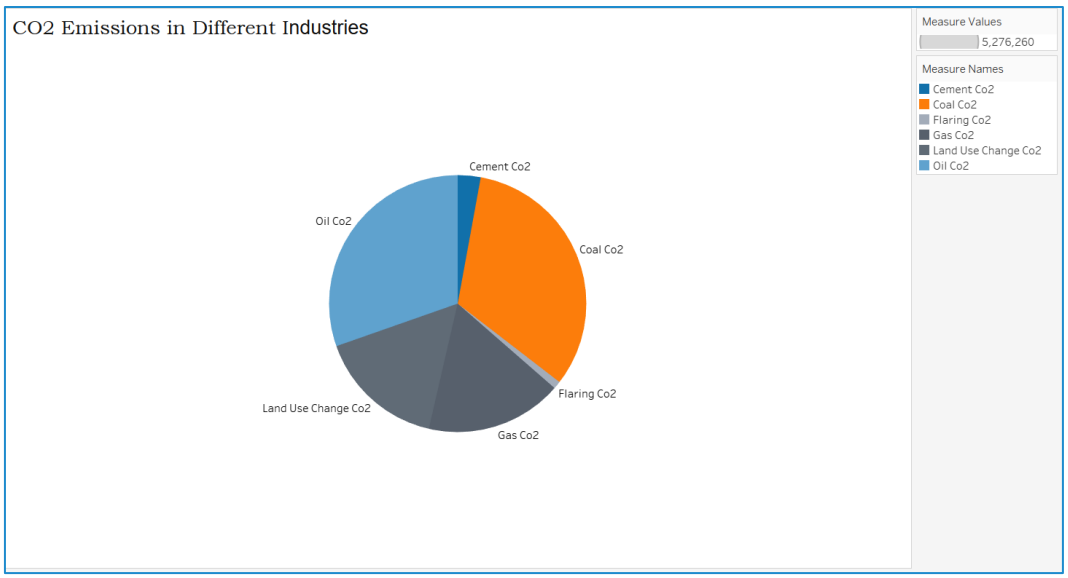

Figure 4.2 CO2 Emissions in Different Industries

Figure 4.3 contrasts worldwide carbon dioxide emissions by the demographic increase from 1989 to 2020, where K represents CO2 emissions on the right y-axis and B stands for global population on the left y-axis. Over time, both CO2 emissions and population are increasing as seen from the chart. It is important to note that since the last century, particularly since the middle of the 20th century, CO2 emissions have increased rapidly as the global population has rapidly increased. The interrelation between human activities, population dynamics, and the growth of CO2 releases is herein posited accentuating the significance of industrialization and modernization on environment.

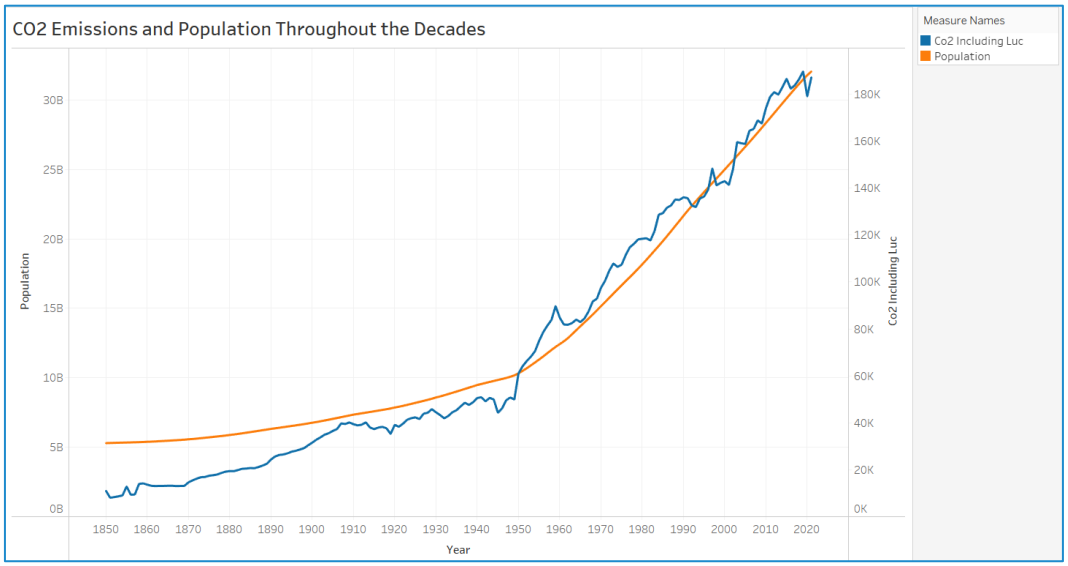

Figure 4.3 CO2 Emissions in Different Industries

Cumulative Emissions

Figure 4.4 displays increased CO2 emissions on yearly basis; these emissions vast by sources 1989-2020. Cement, coal, flaring, gas, land use change (Luc), and oil are each represented by a segment in each bar. The chart shows that CO2 emissions have been rising a lot in the last 30 years. Coal and oil stand out more than gas & land use changes indicate their larger shares. In comparison, a small part of total emissions was contributed by cement production and flaring. It emphasizes consistent patterns of increase particularly from fossil fuels which reflect increasing environmental harm caused by industrial activities from time immemorial.

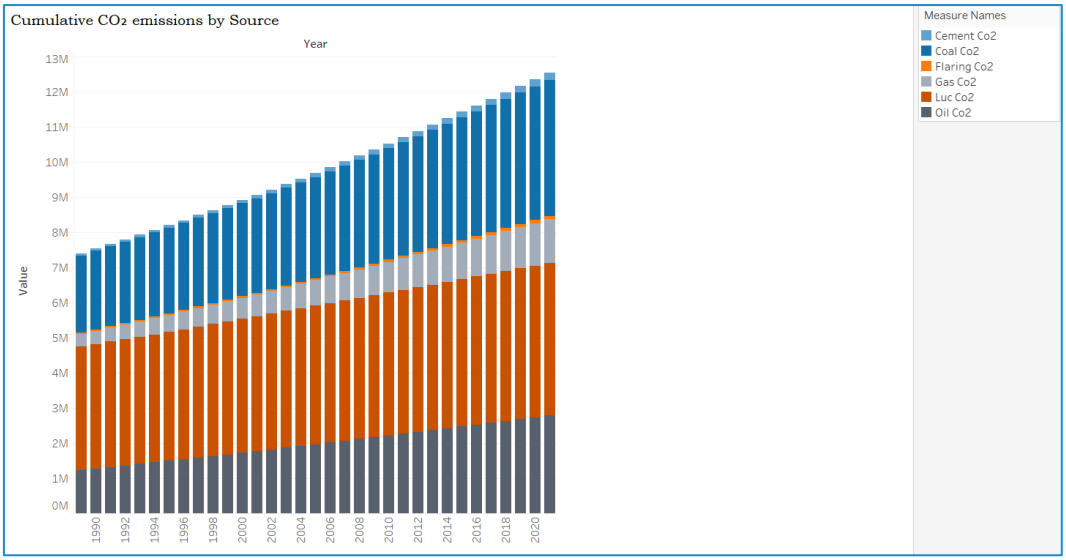

Figure 4.4 Cumulative CO2 Emissions by Source

Figure 4.5 shows how much of the CO2 emissions originate from different production sectors. The chart is divided into sections, each assigned a different representative colour of Cement, Coal, Flaring, Gas, Land Use. Change (Luc), and Oil. Coal CO2 emissions cause serious environmental pollution, with Land Use Change (Luc) and Oil CO2 emissions behind, which means that cumulative emissions are mainly contributed by them–we know this from their scale of production. Gas emissions are however smaller than Flaring or Cement ones but not really by much. Here we see that the largest amount of CO2 is cumulative coming from coal and changes in land use- these are among the aspects that need to be looked at if we want to decrease our carbon footprints globally.

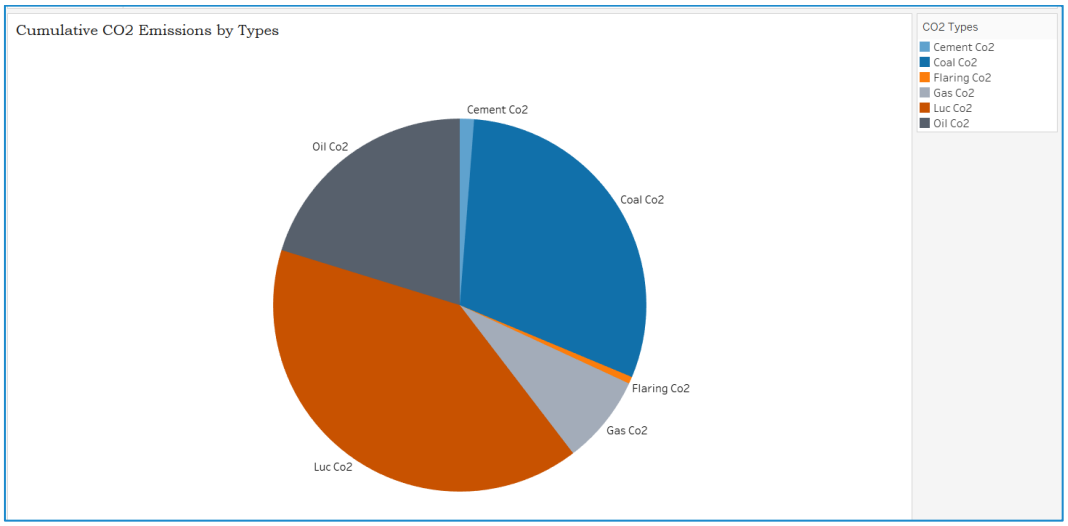

Figure 4.5 Cumulative CO2 Emissions by Types

Figure 4.6 displays what percentage of emissions come out of Africa, South Asia or America among others during rallies from 1988 through 2022. The chart reveals that North America and Europe have, in the past, accounted for most of the world's cumulative carbon dioxide emissions. Meanwhile, there is an increasing trend whereby more and more emissions are coming from Asia; this makes it a major contributor over time. Conversely, Africa, Oceania as well as South America make very small contributions compared to these other continents. A trend that has been experienced recently is that there is an increase in the number of emissions emanating from Asian countries as seen in the chart below.

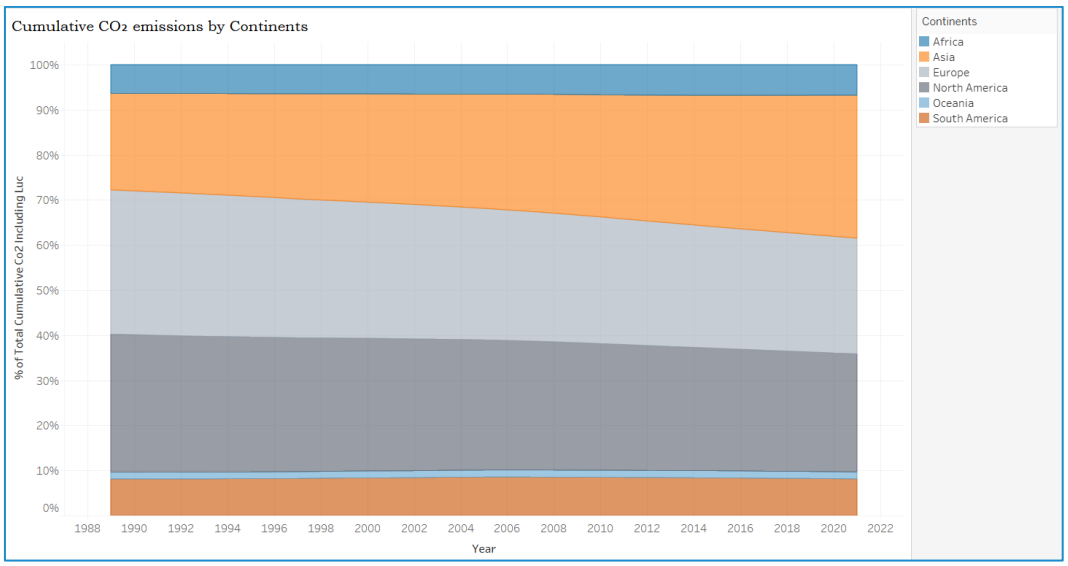

Figure 4.6 Cumulative CO2 Emissions by Continents

Global Contributions

Figure 4.7 shows the percentage share of carbon dioxide production for different nations each year throughout 2021. The shading of maps changes from light Gray coloration to a darker shade which indicates larger proportion of carbon emission in the world. Among all emitters, Gray indicates that China makes the highest contribution to this factor, with black highlighting the similar key role played by the U.S. Other parts like Europe, Russia and India have these regions coloured differently as they emit different amounts of carbon dioxide into the atmosphere.

Figure 4.7 Share of Global CO2 Emissions

Figure 4.8 is a visualization of CO2 emissions distribution by countries in terms of their economic categories in 2021. Each bubble is showing an index of global CO2 emissions from different countries. A 47.11% share of it is held by upper-middle-income countries while high-income ones take up 34.93%. As for the lower-middle income ones, they contribute 17.39% and finally, the low-income 0.57%. This graphic evidence underscores how upper-middle and high-income countries do contribute substantially to carbon dioxide output that emanates from economic activities and industries within their borders.

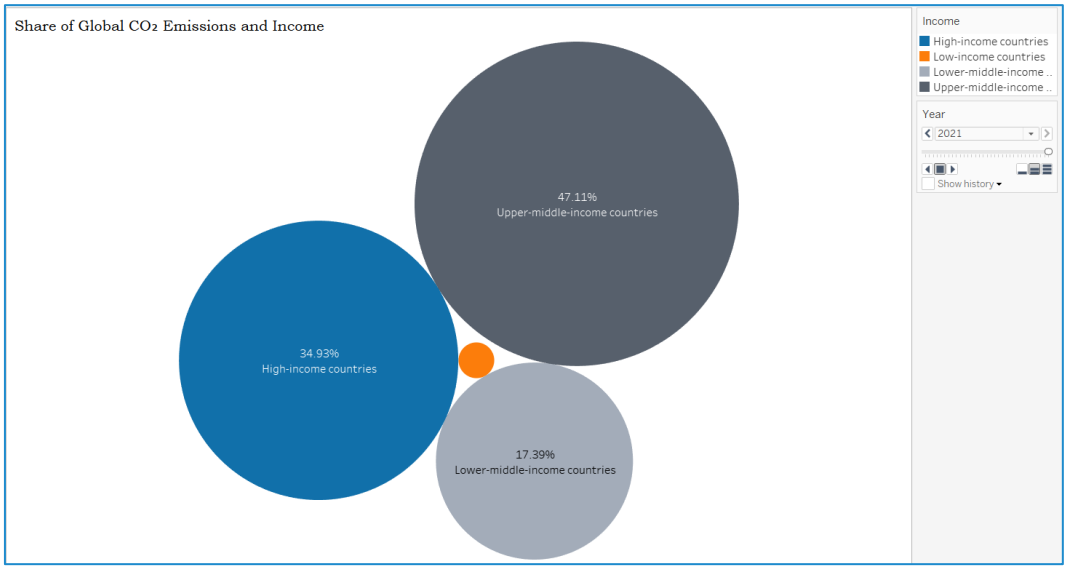

Figure 4.8 Share of Global CO2 Emissions and Income

Figure 4.9 represents the distribution of Co2 emission among various sources across different nations based on income categories. It segments the emissions into Cement, Coal, Flaring, Gas and Oil in terms of high, upper middle, lower middle- and low-income nations. In the hierarchy of CO2 emissions, high-income countries emit the most CO2 due to coal and oil while upper-middle-income countries follow with a lot of coal involved. Lower-middle-income countries emit less in total due to a wider spread across different sources. As for low-income nations they release the smallest amount of CO2 to the atmosphere.

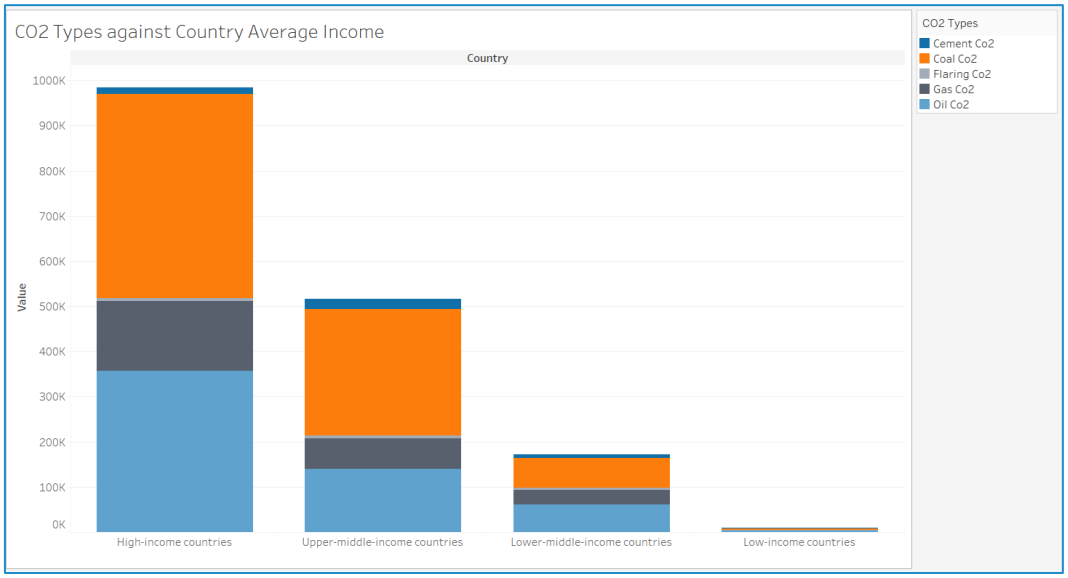

Figure 4.9 CO2 Types Against Country Average Income

Climate Impact and Temperature Change

Figure 4.10 represents cumulatively how well CO2, CH4 (Methane), and N2O (Nitrous Oxide) have contributed to changes in global temperatures over time from 1850 until now known as; “Temperature Change of the World Throughout the Decades”. The chart is divided into three separate areas with CO2 being orange shaded while CH4 is blue hence and represents nitrous oxide by Gray. Each shade area equals out to the mean rise in temperature due to each gas. Data indicates that global temperatures have increased significantly over the years, CO2 being the leading contributor towards these changes, followed by CH4 and N2O. The sharp rise after which levels turned stable to mid-20th century points out how fast air pollutants are affecting our planet’s climate; this stresses why we must all come up with ways of reducing them if we are going save our world from overheating because of increasing temperatures.

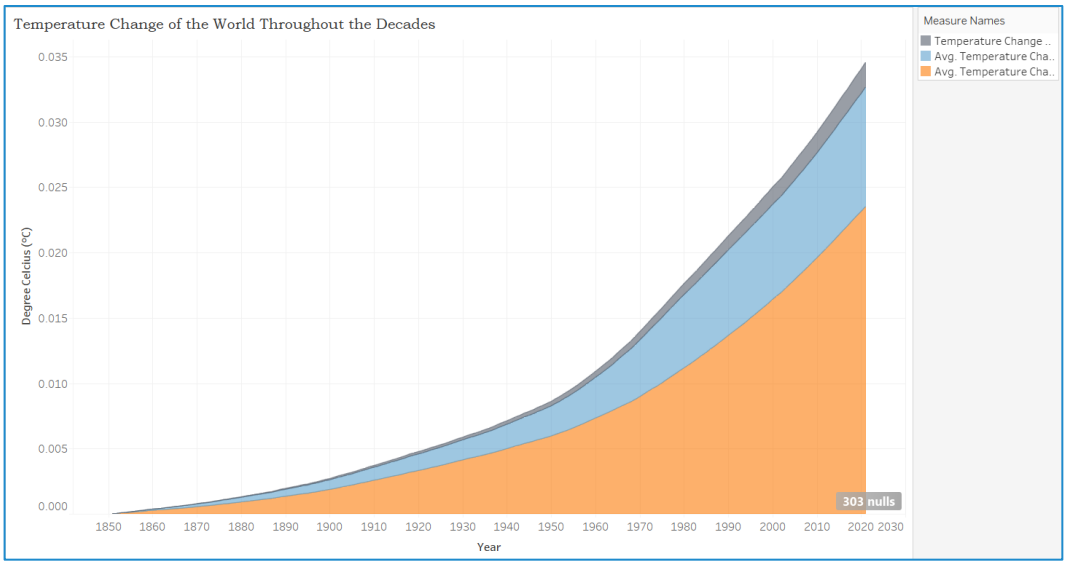

Figure 4.10 Temperature Change of the World Throughout the Decades

Figure 4.11 displays the evolution of CO2, Methane and Nitrous Oxide emissions together with the global temperature fluctuations between 1988 until 2021. The left y-axis represents greenhouse gas emissions in million tonnes (Mt), whereas the right-side measures changes in temperature as per degree Celsius (°C). The orange line represents the trend of CO2 emissions which are seen to have risen steadily from year 2010 up to year 2021. In contrast, methane emission levels remained constant even though there were slight rises observed around 2012 while nitrous oxide witnessed less fluctuation over time since they were within narrow limits starting around 2014 till date. The trend for global warming though remains positive as seen on the grey average temperature increase.

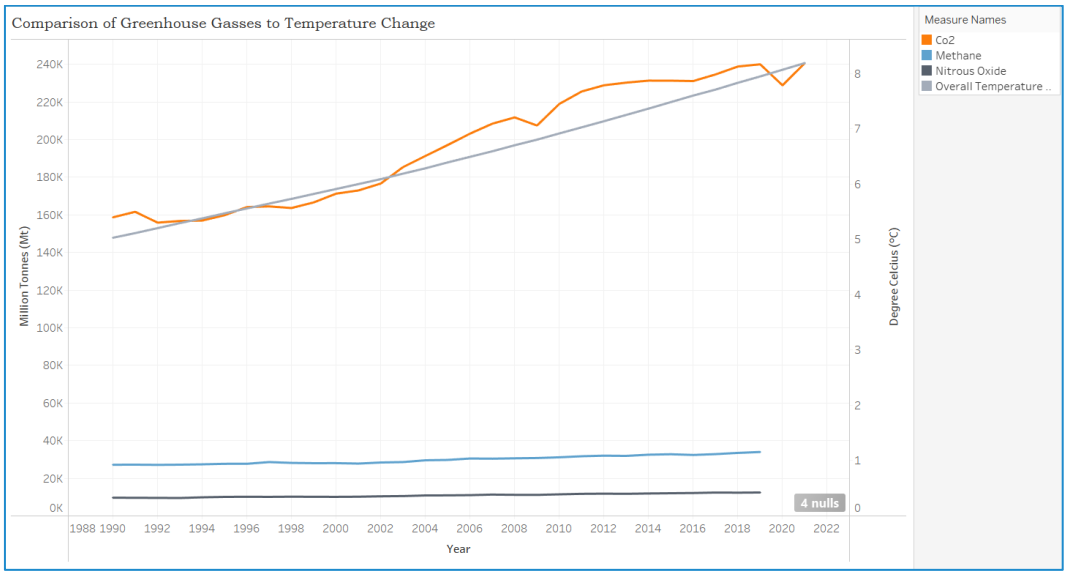

Figure 4.11 Comparison of Greenhouse Gasses to Temperature Change

Figure 4.12 shows the impact of global temperature change by different countries in degree Celsius (°C) as shown in Figure 4.12. The chart is divided into sections based on CO2 (orange), CH4 (Methane, blue), and N2O (Nitrous Oxide, gray) contributions to temperature change. The United States takes the lead on this list with the most significant rise in temperature which mostly comes from CO2 emissions. Russia, China, and India also have significant contributions, with varying proportions from CO2, CH4, and N2O. Other countries, including the United Kingdom, Brazil, Germany, and Indonesia, show notable contributions as well.

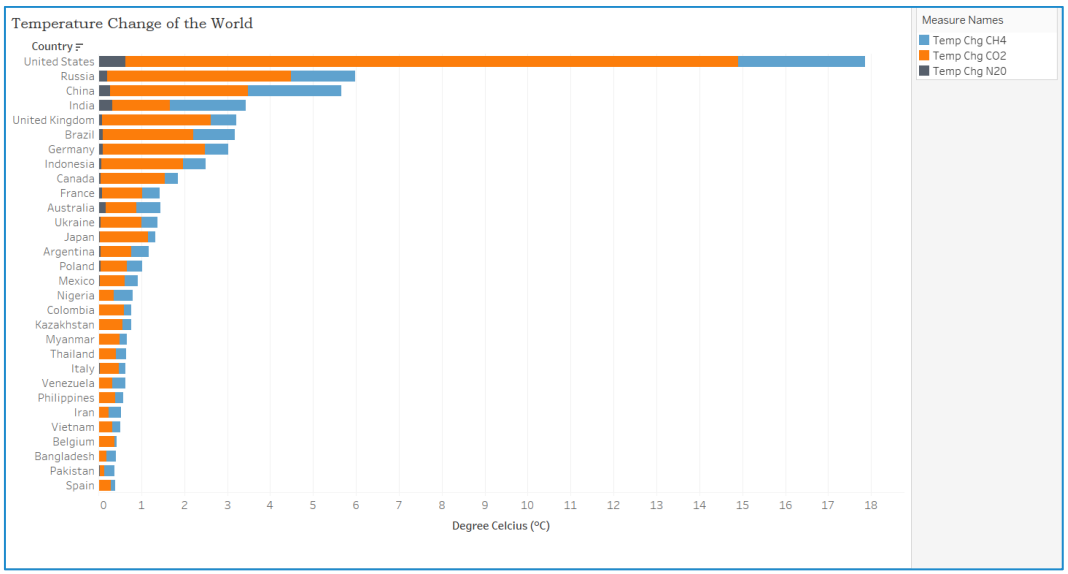

Figure 4.12 Temperature Change of the World

Figure 4.13 indicates how much different greenhouse gases have contribute to changes in world temperatures. It has three gases (CO2, CH4, and N2O) in respective percentages. Carbon Dioxide accounts for the largest share, which is 67.66% and Methane comes second by taking 27.60%. In the meantime, a smaller proportion of the total is made up by Nitrous Oxide at 4.73%. This visualization underscores the importance of cutting down on emissions while focusing more on cutting back emission of CO2 than any other Greenhouse gas to mitigate climate change.

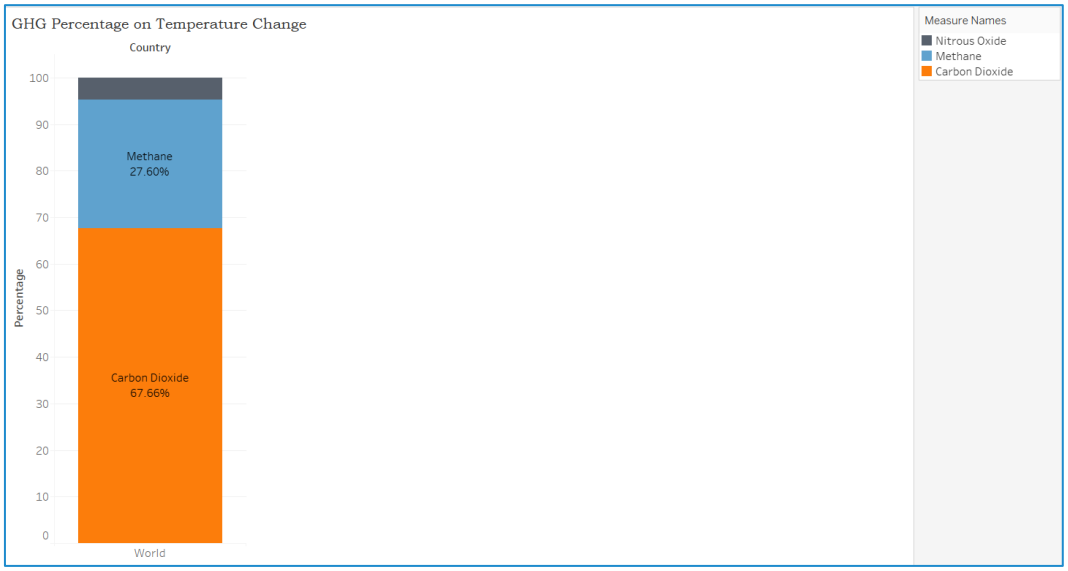

Figure 4.13 GHG Percentage on Temperature Change

5. Conclusion

Our comprehensive analysis of global CO2 and other greenhouse gasses (GHG) emissions reveals critical insights into the historical trends, sector-specific contributions, and the effectiveness of policies aimed at mitigating climate change. This report synthesizes data spanning multiple decades and sectors to provide a nuanced understanding of the drivers and implications of GHG emissions.

The Rise of CO2

Unveiling the intricate story behind rising global CO2 emissions, our data analysis paints a concerning picture. A clear upward trend emerges, paralleling population growth, particularly the dramatic surge observed between 1949 and 1959. While population undeniably plays a role, a deeper dive reveals a more significant culprit - the intertwined forces of industrialization and economic development. Cement production, coal-fired power plants, gas extraction and processing, and oil refineries emerge as the major culprits within these sectors, spewing forth CO2 emissions at an alarming rate. This concerning trend underscores the urgent need for a multi-pronged approach. We must craft targeted interventions and sector-specific policy measures. Only through such a comprehensive strategy can we effectively curb emissions, foster innovation towards cleaner technologies, and ultimately transition towards a more sustainable future for our planet.

Cumulative Emissions

By delving into historical emissions data segmented by both industry and continent, we gain a deeper understanding of the major contributors to this global challenge. The data reveals a stark reality: Asia, North America, and Europe stand out as the biggest cumulative emitters of CO2. Furthermore, zooming in on specific sectors, we see that gas, oil, and coal (excluding land-use change) are the primary culprits. This historical perspective not only highlights the need for global action but also underscores the equity dimensions of climate change. The legacy of past emissions from developed regions necessitates a framework that acknowledges historical responsibility and promotes a just transition towards a sustainable future for all.

Global Contributions

By scrutinizing the distribution of global CO2 emissions across countries and regions, we can pinpoint the major contributors and shed light on the evolving landscape of emitters. While we might have initially anticipated high-income countries to dominate CO2 emissions, a surprising trend emerges: upper-middle-income countries hold the largest share. This unexpected finding underscores the crucial role of emerging economies in the global emissions picture. Furthermore, the stark disparity between high-income and low-income countries, evident in both their CO2 emissions and income levels, necessitates a differentiated approach to climate action. Developing a framework that acknowledges these economic realities and assigns responsibility based on historical contributions and current capabilities will be critical in achieving a truly sustainable future.

Climate Impact and Temperature Change

The correlation between greenhouse gas emissions and global temperature change is evident, with CO2 being the primary driver of lobal warming. However, the significant contributions of methane and nitrous oxide also necessitate a comprehensive approach to emissions reduction. Historical and current temperature data reflect and alarming upward trend, underscoring the urgency of immediate and sustained efforts to mitigate climate change. That said, it is known that on the Year 2008 and Year 2019 there were significant international agreements to CO2 emissions which showed a significant sudden decrease in CO2 emissions. This proves that efforts to mitigate climate change will be able to show immediate effect.

Final Remarks

By leveraging detailed data and trends, this report aims to better understand the challenges and opportunities in addressing climate change. The findings highlight the importance of immediate action and sustained efforts to work towards a more sustainable world.