Analyzing Carbon Emissions of the Philippines and Singapore

A Data Visualization Study Using Power BI

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Table of Contents

Acknowledgment

I would like to express my sincere gratitude to my instructor and the entire Eskwelabs Data Analytics Bootcamp team for their continuous guidance and encouragement throughout my learning journey.

This practice project, although introductory in nature, played a vital role in helping me apply data visualization skills and build confidence in using Power BI for exploratory data analysis.

Introduction

Carbon emissions are a major driver of climate change and environmental degradation. Analyzing emissions at the country level reveals important patterns related to industrial activity, energy usage, and economic development.

This study focuses on two countries — the Philippines and Singapore — whose contrasting economic and developmental profiles make their comparison particularly compelling. Using Power BI, this project explores CO_2 emissions through multiple lenses: total emissions over time, emissions by source, global emissions share, and differences across income groups.

Through visual analytics, the study aims to uncover trends, highlight the factors influencing emissions in each country, and provide a data-driven foundation for deeper insights into energy and environmental strategies.

Objectives of the Study

The primary objective of this study is to conduct an exploratory and comparative analysis of carbon dioxide (CO_2) emissions between the Philippines and Singapore, using data visualization techniques in Power BI. Specifically, the study seeks to:

- Identify the year with the highest carbon emissions for each country and understand how emission trends have evolved over time.
- Analyze the population trends in the Philippines and Singapore, and examine their potential relationship with changes in carbon emissions.
- Investigate whether population growth serves as a significant factor influencing carbon emission levels.
- Evaluate the performance of the Philippines and Singapore in the context of global CO_2 emissions, assessing their relative contributions on the world stage.
- Determine which among the emission sources—namely cement, coal, gas flaring, gas production, and oil production—has the greatest impact on total CO_2 emissions for each country.
- Compare how CO_2 emissions from different sources vary when classified according to income group, particularly between a lower-middle-income country (the Philippines) and a high-income country (Singapore).
- Synthesize findings to build a comprehensive comparative profile of the two countries in terms of their CO_2 emissions patterns, sources, and broader environmental impacts.

Through these objectives, the study aims to foster a deeper understanding of how economic structure, energy reliance, and demographic factors interplay with environmental outcomes in

contrasting national contexts. Furthermore, this project serves as an opportunity to strengthen essential skills in data wrangling, visual analytics, data storytelling, and critical thinking—skills vital for advancing in the field of data analytics.

Significance of the Study

Understanding carbon emission trends is crucial not only for environmental protection but also for promoting sustainable economic development. By examining the trajectories of carbon emissions in the Philippines and Singapore—two countries with differing economic profiles—this study provides valuable insights into how industrial activities, population growth, and energy reliance shape environmental outcomes. Such an analysis can inform future strategies for balancing development with environmental stewardship.

Beyond the environmental insights gained, this project also emphasizes the importance of data-driven storytelling. Using Power BI, a leading data visualization tool, the study demonstrates how visual analytics can uncover patterns, trends, and comparisons that may not be immediately evident from raw data alone. By applying a structured approach to comparative analysis, this project showcases the critical role that visualization, interpretation, and contextual understanding play in transforming data into actionable knowledge.

Furthermore, conducting an analysis of this nature fosters essential competencies for the modern data professional. It reinforces critical thinking, hones technical skills in data wrangling and visualization, and strengthens the ability to derive meaningful conclusions from complex datasets. Most importantly, it highlights the relevance of data analytics in addressing global sustainability challenges—a perspective that is increasingly important across industries today. This project therefore serves not only as an academic exercise, but also as a demonstration of how analytics can contribute to real-world decision-making for a more sustainable future.

Dataset Description

The data used in this project was sourced from publicly available datasets compiled by reputable organizations such as **Our World in Data**, the **Carbon Dioxide Information Analysis Center (CDIAC)**, and the **Global Carbon Project**. It includes a comprehensive range of metrics related to carbon dioxide (CO_2) emissions, energy consumption, population, gross domestic product (GDP), and more, spanning across different countries and multiple years.

Key variables within the dataset include country, year, population, GDP, total CO_2 emissions, CO_2 emissions broken down by source (cement, coal, gas flaring, gas production, and oil production), share of global CO_2 emissions, as well as region and income group classifications. These fields provide a rich basis for both time-series analysis and cross-sectional comparisons, allowing for a multi-dimensional exploration of carbon emission patterns.

The dataset's structure enables the investigation of trends over time and across different economic contexts, making it particularly well-suited for the comparative analysis conducted in this study. By focusing on the Philippines and Singapore, the data supports an in-depth

examination of how varying economic development levels, energy strategies, and industrial activities influence carbon emissions.

Methodology

This study adopts an **exploratory and descriptive data analysis** approach to investigate carbon emissions trends between the Philippines and Singapore. The methodology was structured in several key stages.

First, **data filtering** was conducted to narrow the scope of the dataset exclusively to records pertaining to the Philippines and Singapore. This ensured that the analysis remained focused and relevant to the study objectives.

Next, **data visualization** techniques were employed using **Power BI**. Various charts and visual representations were created to illustrate trends, comparative differences, and relationships across multiple dimensions, such as time, emission sources, and income group classifications. Visual exploration enabled the identification of significant patterns and disparities between the two countries.

Following the creation of visual outputs, a phase of **simple interpretation** was undertaken. Key insights were derived by observing and analyzing the patterns presented in the visualizations. The analysis emphasized descriptive findings without attempting to establish causality or make predictive forecasts.

It is important to note several **limitations** of this methodology.

- This project does not involve predictive modeling, advanced statistical inference, or causal analysis techniques.

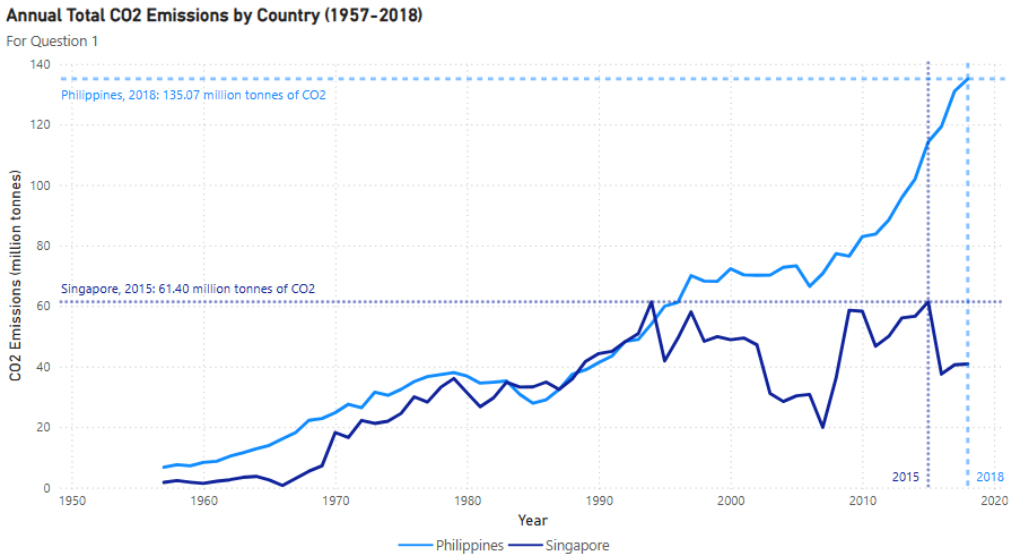
- The insights are based solely on the provided dataset, without cross-validation against external data sources or real-world policy documents.

Despite these limitations, the exploratory nature of the methodology effectively supports the study's aim of building foundational understanding through visualization and descriptive analysis.

Results and Discussion

Highest Year for Carbon Emissions

The chart shows that the **highest carbon emissions** in the **Philippines** occurred in **2018**, reaching **135.07 million tonnes**, while **Singapore** recorded its peak earlier in **2015**, with **61.40 million tonnes**. Although both countries experienced overall growth in emissions over time, their peak periods occurred in different years, suggesting that distinct economic, industrial, or environmental factors shaped their trajectories.



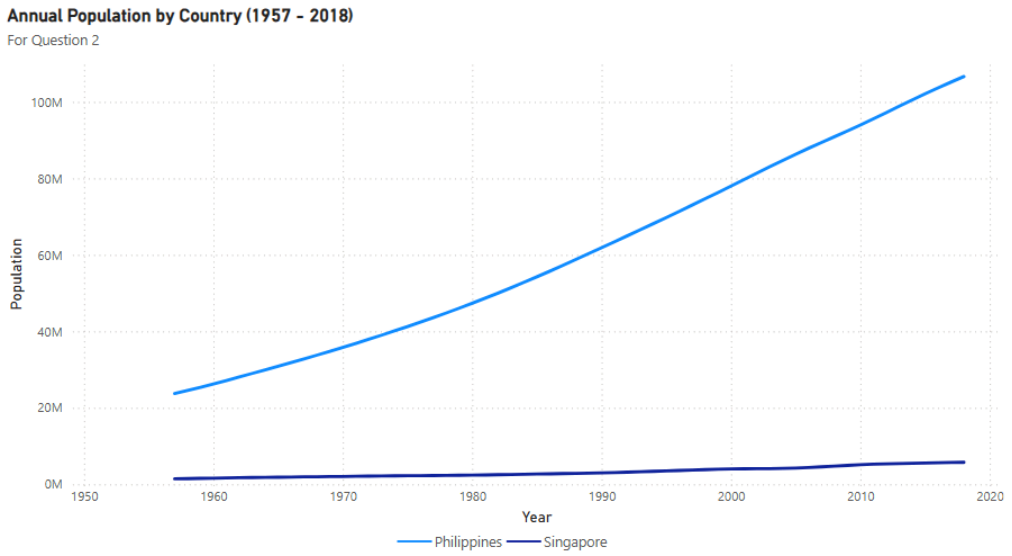
For the Philippines, the peak in 2018 may be attributed to rapid urbanization, industrial expansion, and increased energy consumption driven by economic growth during that period. In contrast, Singapore's carbon emissions story appears more nuanced. Singapore had already recorded a comparable level of emissions as early as **1994**, with **61.35 million tonnes**. After 1994, emissions fluctuated but generally followed a decreasing trend before reaching a renewed peak in 2015. Since 2015, Singapore's emissions have shown signs of a steady decline. This pattern may reflect the impact of industrial transitions, improved energy efficiency measures, or the adoption of more stringent environmental policies over time.

It is also notable that the scale of emissions differs significantly between the two countries. Even at their respective peak years, the Philippines' emissions were more than twice those of Singapore. This disparity reflects not only differences in population size but also variations in economic structures, industrial activities, and energy sources used by each country.

Identifying these peak years and observing emission patterns over time provide important baselines for further analysis. They allow for the evaluation of the effectiveness of national carbon reduction strategies and can offer valuable insights into the relationship between economic development and environmental impact. Understanding these trends is essential in framing future policies aimed at achieving sustainable growth while minimizing carbon footprints.

Population Trend Analysis

To explore the overall trajectory of population changes in the Philippines and Singapore, a line chart was developed showing the annual population estimates for both countries over the period 1957 to 2018.



Observations and Insights on Annual Population Trends

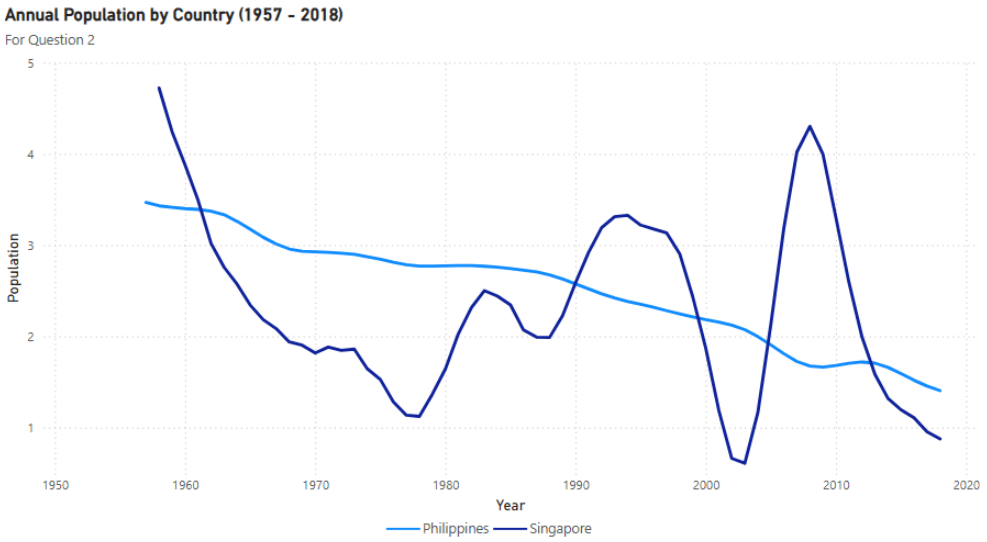
From the chart, it is evident that both the Philippines and Singapore have experienced an upward trajectory in population over the 61-year period. However, the magnitude and steepness of the population growth differ greatly between the two countries. The Philippines shows a significantly steeper and more consistent rise, starting from approximately 23.7 million in 1957 and reaching over 100 million by 2018. Singapore, on the other hand, exhibited a comparatively flatter trend line, growing from about 1.4 million to roughly 5.7 million in the same period.

The stark difference in population size between the two nations is clearly visualized, and it becomes immediately apparent that the Philippines has consistently maintained a much larger population base. The trend line for the Philippines reflects a steady and accelerating increase, whereas Singapore's line, although upward, appears far more subdued due to the scale of the graph accommodating the much larger Philippine values.

While this initial visualization effectively highlights the difference in absolute population numbers, it can obscure finer details about the nature of the population change, particularly for Singapore, whose variations are visually minimized when plotted alongside a country with a much larger population base.

Population Growth Rate (%) by Year and Country

To gain deeper insights into the dynamics of population changes, a second line chart was created illustrating the **annual population growth rates (%)** of both countries over time. Unlike absolute population numbers, growth rates measure the relative year-on-year percentage increase in population.



The second chart reveals a more nuanced and dynamic picture of population trends that was not fully captured by the previous population chart. For the Philippines, there is a general declining trend in the population growth rate from 1957 to 2018. Starting at a relatively high growth rate above 3%, the Philippines' growth rate gradually decreased to 1.4% toward the end of the observed period. This indicates that while the total population continues to rise in absolute terms, the **rate of increase is slowing down**—a typical pattern seen in countries undergoing demographic transitions toward lower birth rates.

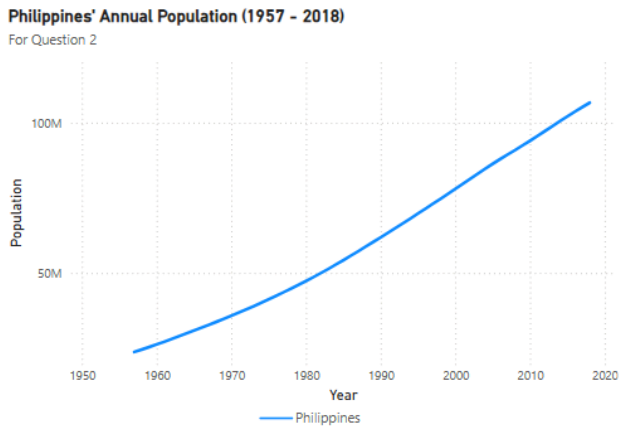
In contrast, Singapore's growth rate displays a much more volatile pattern. The growth rate sharply declined in the 1960s and 1970s, then experienced periods of acceleration and deceleration from the 1980s onwards. Notably, Singapore's growth rate even surpassed that of the Philippines at certain points, especially during the late 1980s and mid-2000s, due to specific socio-economic policies such as immigration programs aimed at supplementing the local population.

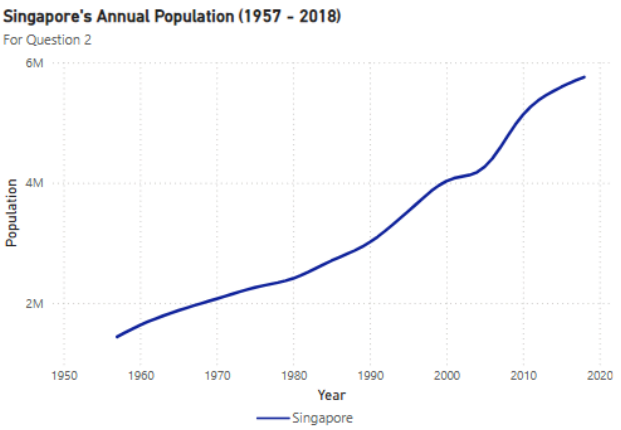
This comparison highlights a key point: **a steadily increasing population does not necessarily imply a constant or increasing growth rate.** While the population line chart suggested a continuous upward movement, the growth rate chart reveals that both countries experienced a **deceleration** in the pace of population expansion over time.

Furthermore, when both countries' populations are presented in a single line chart (as in the first visualization), the characteristics of the country with the smaller population (Singapore) are **visually marginalized**. The larger numerical range of the Philippines' population causes Singapore's population trend to appear almost flat, masking the internal fluctuations and changes in its growth pattern. This limitation underscores the importance of tailoring data visualizations to the scales and ranges appropriate for the subjects being compared, particularly when significant disparities exist between them.

Separate Population Trends for Philippines and Singapore

To address this visualization issue, two separate line charts were created: one for the Philippines and one for Singapore.





When the population trends are analyzed separately, the characteristics of each country's population growth become more distinctly visible. For the Philippines, the continuous upward trend is reaffirmed. For Singapore, the separate chart reveals periods of more rapid population growth, notably in the 1990s and 2000s, periods which were previously obscured when plotted alongside the Philippines.

This approach emphasizes how disaggregated visualizations can help reveal subtle but important patterns that may be lost when different entities with highly unequal scales are plotted together. It allows for a clearer understanding of each country's demographic dynamics without the distortion introduced by large disparities in magnitude.

Quantification of Overall Population Growth: Compound Annual Growth Rate (CAGR)

To summarize and quantify the overall trends, the **Compound Annual Growth Rate (CAGR)** was calculated for each country. The CAGR provides a smoothed annualized growth rate over the period 1957 to 2018, capturing the average year-on-year percentage increase in population, assuming a steady rate of growth.

The formula used is:

$$CAGR = \left(\frac{Population\ at\ End\ Year}{Population\ at\ Start\ Year}\right)^{\frac{1}{Number\ of\ Years}} - 1$$

Applying the formula to the available data yields the following results:

Country	Population (1957)	Population (2018)	CAGR (%)
Philippines	23,752,000	106,651,000	2.49%
Singapore	1,440,000	5,758,000	2.30%

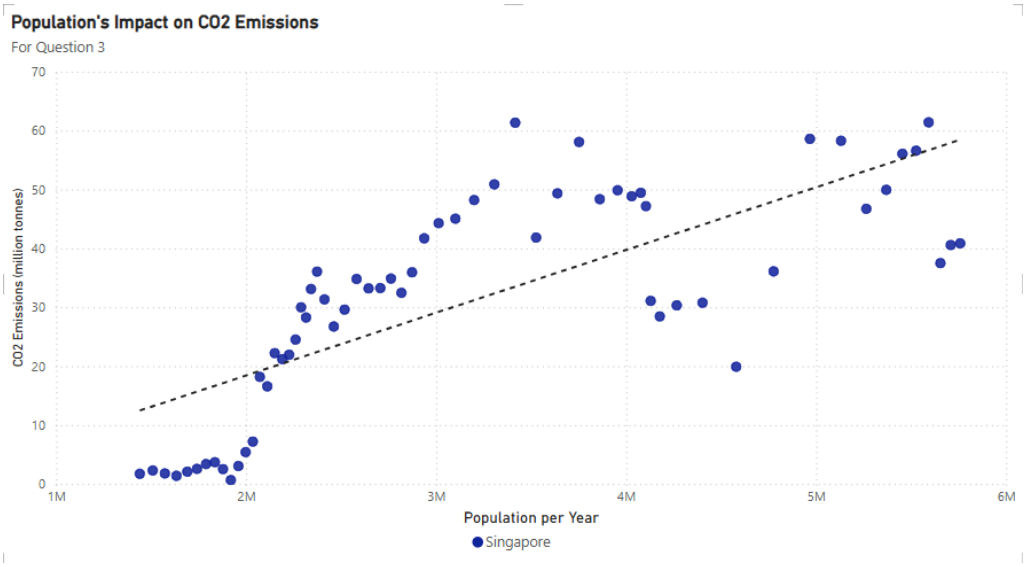
The table above reveals that, although both countries exhibited strong population growth over the six-decade period, the Philippines' average annual population growth rate was slightly

higher at approximately **2.49%**, compared to Singapore's **2.30%**. This quantification complements the visual analyses, providing a clearer summary of the long-term demographic dynamics of the two countries. The higher CAGR for the Philippines reflects its consistently larger and faster-growing population base relative to Singapore, despite both countries experiencing a general deceleration in growth rates over time.

Relationship Between Population and Carbon Emissions

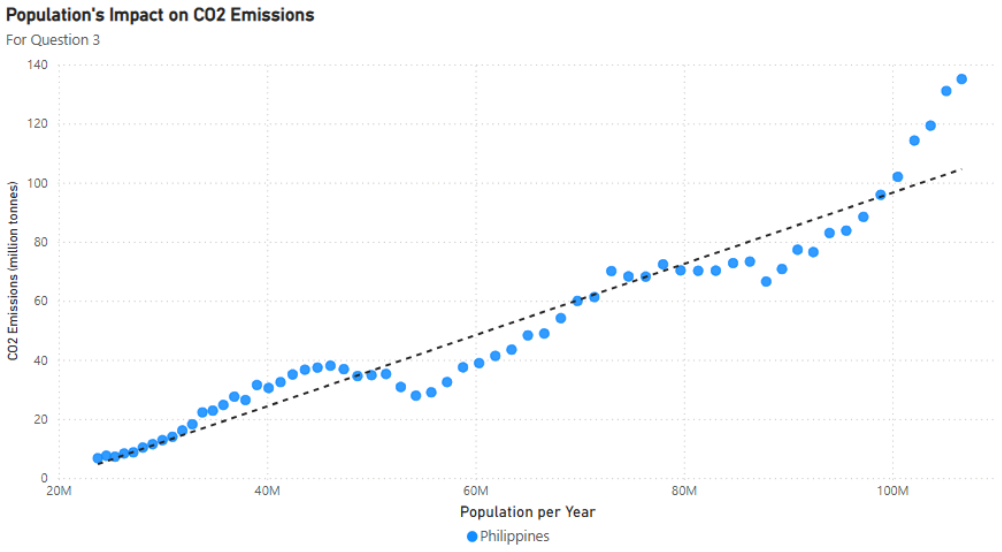
To assess whether population growth influences carbon emissions, scatter plots were generated for both Singapore and the Philippines, plotting *Population per Year* against *CO_2 Emissions (in million tonnes)*. The analysis for each country revealed important insights about the nature of this relationship.

For **Singapore**, the scatter plot shows a clear positive correlation between population size and CO_2 emissions. As the population expanded from around 1 million to nearly 6 million, CO_2 emissions increased from under 10 million tonnes to over 40 million tonnes. The positive slope of the trendline reinforces the existence of this relationship. However, the chart also reveals periods where emissions plateaued or fluctuated even as the population continued to grow. These non-linear segments suggest that while population is a significant factor, other elements—such as economic restructuring, energy policies, or advances in technology—also influence emissions trends. Notably, deviations from the general upward pattern may correspond to years of policy intervention, shifts in industrial composition, or economic slowdowns.



In contrast, the **Philippines** exhibits a more consistently linear positive relationship between population growth and carbon emissions. As the population grew from approximately 20 million to over 100 million, carbon emissions rose in parallel from around 10 million tonnes to over 100 million tonnes. The steady, upward trajectory of the trendline suggests a strong and direct association between increasing population and rising carbon emissions, with fewer instances of deviation or plateau compared to Singapore. This consistency implies that population growth plays a particularly dominant role in shaping carbon emissions in the Philippine context,

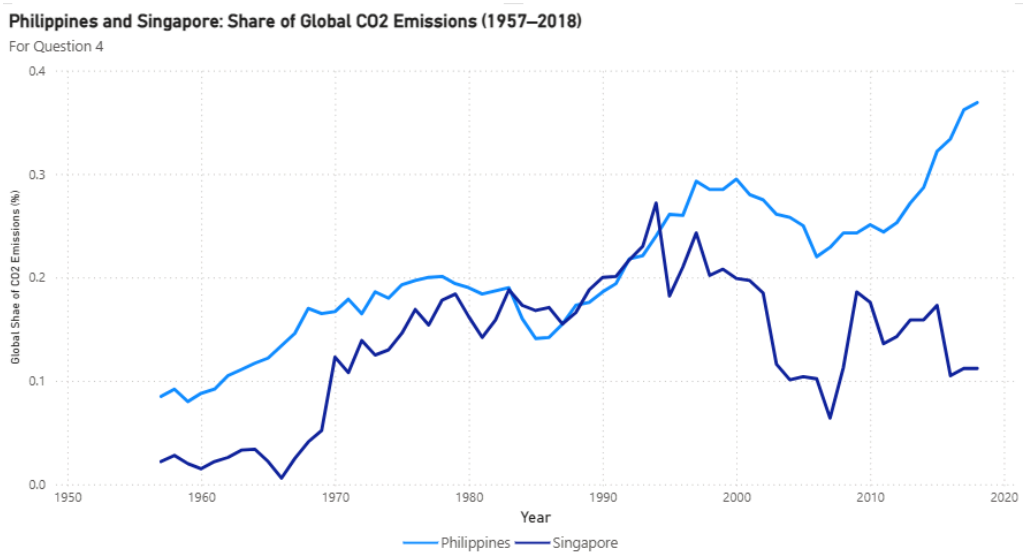
although factors such as energy sources, urbanization, and economic development also contribute.



Comparatively, both countries demonstrate that population is an important factor in carbon emissions; however, the relationship is more straightforward in the Philippines than in Singapore. Singapore's carbon emissions are also shaped significantly by factors external to population dynamics, such as energy efficiency measures, policy decisions, and industrial transformations. Meanwhile, the Philippine case reflects a more direct and sustained connection between demographic growth and increased emissions.

In summary, population growth is a significant driver of carbon emissions for both Singapore and the Philippines, although the complexity and strength of this relationship vary between the two countries. This highlights the necessity of considering additional socio-economic and policy factors when analyzing environmental impacts related to demographic changes.

CO_2 Emissions Performance Compared to the World



To understand how the Philippines and Singapore have contributed to global carbon emissions over time, a line chart was created showing each country's share of global CO_2 emissions from 1957 to 2018. This visualization highlights long-term trends and enables a comparative analysis of the two countries' relative contributions to global emissions.

For the **Philippines**, the overall trend reveals a gradual and consistent increase in its share of global carbon emissions. From 1957 through the early 1990s, the Philippines maintained a relatively low share, typically below 0.2%. However, beginning in the early 1990s, there was a noticeable upward shift. By the late 1990s, the country's share had risen to approximately 0.3%, and this growth continued steadily, reaching nearly 0.4% by 2018. This increasing trajectory reflects broader patterns of economic development, industrial expansion, and urbanization that have taken place in the Philippines over the past several decades.

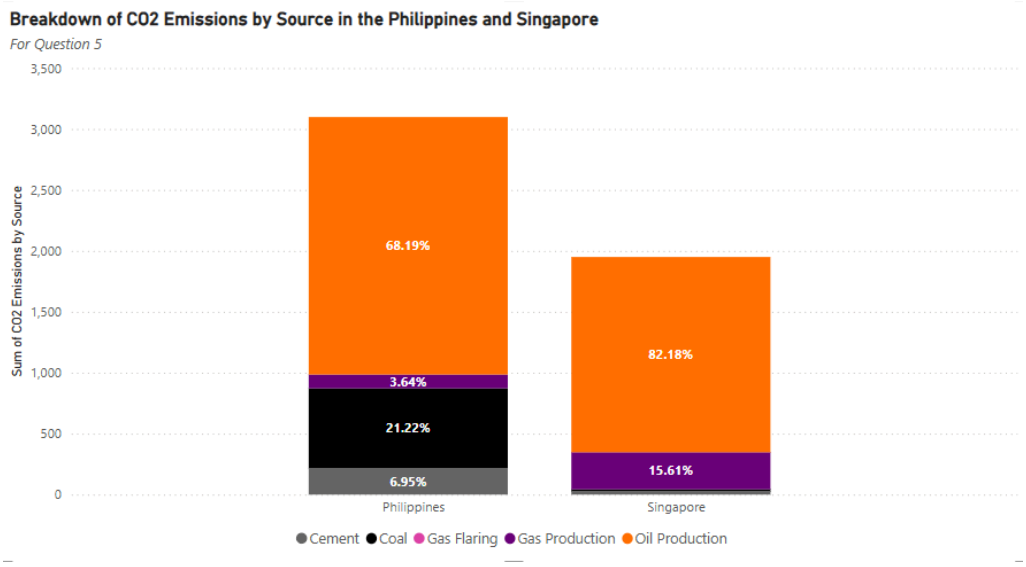
In contrast, **Singapore's** performance shows a different dynamic. From 1957 until the mid-1990s, Singapore's share of global CO_2 emissions steadily grew, eventually surpassing that of the Philippines in the mid-1990s. During this period, Singapore's rapid economic growth, industrialization, and expansion as a global trade and financial hub likely contributed to higher emissions. However, from the late 1990s onward, Singapore's share began to decline and became more variable. Despite fluctuations, the overall trend after its mid-1990s peak indicates stabilization and eventual reduction in its proportion of global emissions. This decline may be attributed to Singapore's strategic policy interventions, including efforts to diversify its energy mix, improve energy efficiency, and transition towards a more service-oriented economy.

When comparing the two countries, several distinct phases emerge. In the **early years (1957–1990s)**, both nations had relatively small contributions to global emissions, with Singapore experiencing faster growth in its share. During the **mid-1990s**, Singapore briefly overtook the Philippines, recording its highest share of global emissions. However, by the **late 1990s onwards**, the countries' paths diverged: the Philippines' share continued to climb steadily, while Singapore's began to stabilize and decrease. By 2018, the Philippines had a higher share of global carbon emissions compared to Singapore.

Overall, the line chart underscores the different trajectories that Singapore and the Philippines have taken in their global carbon emissions performance. While the Philippines reflects a pattern of growing contribution aligned with industrialization and population growth, Singapore's case illustrates the potential impact of proactive policy-making and economic transformation in moderating and even reversing emissions growth.

Impact of Cement, Coal, Gas Flaring, Gas Production, and Oil Production on CO_2 Emissions

The sources of carbon emissions in the Philippines and Singapore were analyzed using a stacked bar chart that displayed the breakdown of CO_2 emissions by sector. This visualization highlights the major contributors to each country's overall carbon footprint and provides insights into the structure of their respective emissions profiles.



For the **Philippines**, **oil production** emerged as the dominant source of carbon emissions, accounting for **68.19%** of total emissions. This was followed by **coal**, which contributed **21.22%**, and **cement production**, which added another **6.95%**. **Gas production** contributed a smaller share at **3.64%**, while **gas flaring** appeared to have a minimal or negligible impact. Overall, the Philippines demonstrates a relatively diverse emissions profile, with significant contributions coming from multiple sectors.

In the case of **Singapore**, the emissions profile is even more concentrated. **Oil production** is by far the largest source, responsible for a staggering **82.18%** of total CO_2 emissions. **Gas production** follows as the second-highest source at **15.61%**. Other sources—such as cement, coal, and gas flaring—appear to have little to no significant contribution to Singapore's carbon emissions. This concentrated emissions structure reflects Singapore's industrial base, which is heavily oriented towards refining, petrochemical processing, and energy trade.

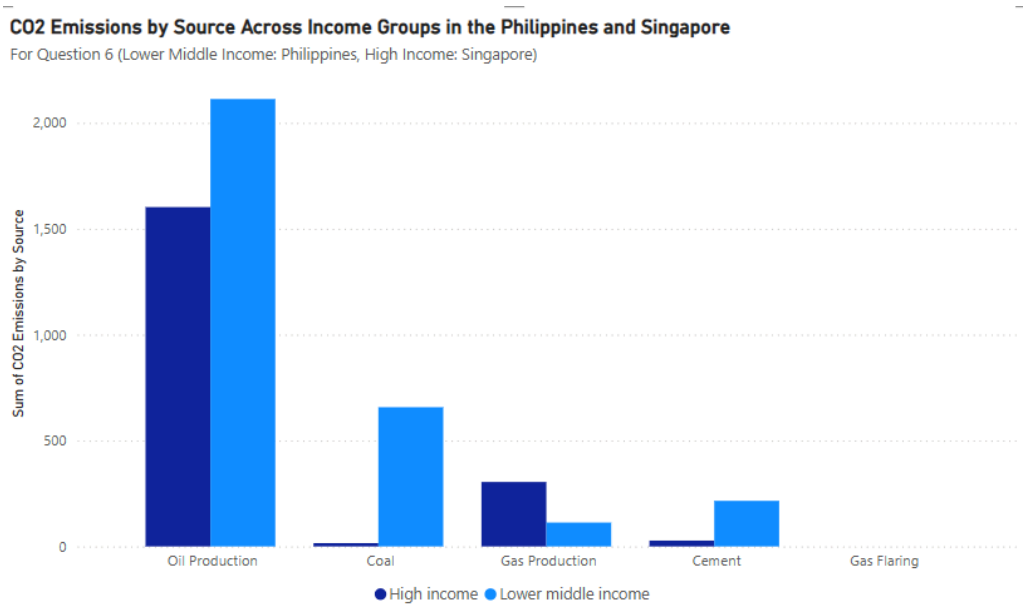
When comparing the two countries, several key differences emerge. While **oil production is the primary source in both nations**, Singapore exhibits a much **higher dependency** on oil (82.18% vs. 68.19%). The **Philippines**, by contrast, has a **more diversified emissions profile**, with substantial secondary contributions from coal and cement sectors. Additionally, the total volume of CO_2 emissions is **higher for the Philippines** (approximately **3,100 units**) compared to Singapore (approximately **2,000 units**), indicating a broader base of carbon-intensive activities despite Singapore's higher reliance on oil.

This analysis underscores the different industrial and energy structures of the two countries: **the Philippines' broader sectoral spread of emissions versus Singapore's concentrated emissions in oil and gas production**. These structural differences have important implications for national strategies to mitigate carbon emissions moving forward.

CO_2 Emissions by Income Group Comparison

The variation in carbon emissions across income groups was examined using a bar chart that compared the Philippines (a lower-middle-income country) and Singapore (a high-income

country) across different emission sources. The analysis reveals clear differences in the composition of carbon emissions based on economic status.



Oil production is a significant source of emissions for both countries. However, the Philippines exhibits slightly higher emissions from oil production compared to Singapore. When it comes to **coal**, emissions are markedly higher in the Philippines, while Singapore's coal-related emissions are almost negligible. This indicates a heavier reliance on coal as an energy source in lower-middle-income economies.

In contrast, **gas production** contributes more substantially to Singapore's emissions compared to the Philippines. This suggests that higher-income countries may have greater access to natural gas infrastructure and technology, which is often viewed as a relatively cleaner fossil fuel compared to coal. **Cement production** emissions are also higher in the Philippines, reflecting the ongoing infrastructure and development activities typical of emerging economies. Meanwhile, **gas flaring** emissions appear minimal for both countries.

Overall, the analysis confirms that **carbon emissions do vary across income groups**, with notable differences in the sources contributing to total emissions. High-income countries like Singapore rely more heavily on **gas production** and have significantly **lower emissions from coal and cement**, suggesting a shift towards cleaner energy and a service-based economy. Lower-middle-income countries like the Philippines remain more dependent on **coal and cement**, reflecting the industrial and developmental needs characteristic of their economic stage.

These patterns highlight the role of economic development, energy policy, and access to technology in shaping the carbon emissions profile of countries at different income levels.

Comparative Summary: Philippines vs. Singapore

The comparative analysis of the CO_2 emissions profiles of the Philippines and Singapore, built across Questions 1 to 6, reveals a nuanced picture of the two countries' carbon footprints.

Overall Emission Trends:
From 1957 to 2018, the Philippines has shown a steady increase in total CO_2 emissions and in its share of global emissions. In contrast, Singapore experienced a faster rise in emissions until the mid-1990s, after which its emissions began to stabilize and decline slightly. This divergence reflects broader differences in economic trajectories: the Philippines continues on a path of industrial growth and infrastructure expansion, while Singapore has transitioned toward a more service-oriented, less carbon-intensive economy.

Sources of Emissions:
In terms of emission sources, both countries rely heavily on **oil production**, but the degree of reliance differs: oil accounts for **82.18%** of Singapore's emissions compared to **68.19%** for the Philippines. The Philippines exhibits a more diversified emission profile, with substantial contributions from **coal (21.22%)** and **cement (6.95%)**, whereas Singapore's emissions are highly concentrated in oil and gas production. Coal and cement emissions are almost negligible in Singapore, suggesting differences in energy choices and industrial composition.

Global Standing:
When comparing their shares of global CO_2 emissions, the Philippines' share has steadily risen, nearing **0.4%** by 2018, while Singapore's share peaked in the mid-1990s before declining. This shift indicates the Philippines' growing contribution to global emissions as its economy develops, whereas Singapore's policy interventions and economic restructuring have curbed its emissions growth.

Income Group Differences:
Comparing emissions by income group reinforces these observations. As a lower-middle-income country, the Philippines depends more heavily on **coal and cement**, common in developing economies pursuing industrialization. Singapore, a high-income country, demonstrates greater reliance on **gas production**, a cleaner alternative to coal, reflecting its access to advanced technologies and more stringent environmental policies.

In summary, the Philippines and Singapore display distinct carbon emissions profiles shaped by their economic development stages, industrial structures, and energy policies.

- **The Philippines** shows an increasing and more diversified emissions profile, reflecting ongoing industrial growth.

- **Singapore** shows a stabilized and concentrated emissions profile, indicative of a mature, service-driven economy with efforts toward emissions reduction.

Together, these insights highlight the complex relationship between economic growth, energy choices, and carbon emissions, emphasizing the importance of tailored policy approaches to managing emissions based on a country's developmental context.

Conclusion

This project served as an in-depth exploration of carbon emissions trends in the Philippines and Singapore, providing a comprehensive comparison using data visualizations built in Power BI. By examining emissions over the course of several decades, key patterns were identified, such as the steady rise in emissions in the Philippines due to industrialization and energy production, as well as the stabilization and decline of emissions in Singapore following policy shifts and economic transitions.

The study began with an analysis of total emissions, which revealed distinct growth trajectories for each country. Through further breakdowns by emission sources, including oil, coal, and cement, we saw how each country's energy mix and industrial strategies influenced their carbon footprints. In addition, the global standing of each nation's emissions was assessed, offering a broader context for understanding their contribution to global carbon output.

Using Power BI's visualization capabilities, I was able to translate complex datasets into accessible, engaging charts and graphs. This allowed for the identification of trends, such as Singapore's initial rise in emissions followed by a period of stabilization, and the Philippines' continuous increase driven by a more diverse energy and industrial base.

This project not only enhanced my technical skills in data wrangling and visualization but also deepened my understanding of how data can tell compelling stories. By combining descriptive analysis with clear, visually rich charts, I was able to present nuanced insights that highlight the importance of economic and energy-related factors in shaping emissions trends. This experience has refined my ability to approach complex datasets, draw meaningful conclusions, and communicate those findings in a way that is both insightful and accessible.

In conclusion, this project illustrates the value of data-driven analysis in understanding global challenges, while also showcasing my capability to leverage advanced visualization tools to produce actionable insights. It is an example of how effective data analysis can support decision-making, particularly in areas critical to global sustainability.