Visualizing Countries' Contributions to Climate Change (Greenhouse Gas Emissions)

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Introduction

Climate change has significantly impacted the environment for decades, largely due to human activities, particularly modern industrialization. The rise in greenhouse gas emissions from industrial activities[1] has increased Earth's surface temperature, trapping heat and preventing cooling[2]. This has led to more frequent heat waves, intense rainfall, and other extreme climate events.

Addressing greenhouse gas emissions is more urgent than ever. Communicating their sources and impacts is crucial for raising awareness and encouraging action. In this project, we built on CNN's visualizations of emissions by country[3] to highlight contributions to greenhouse gas emissions and emphasize the efforts needed to combat climate change. We developed a visualization of the top 10 greenhouse gas emitters per capita in 2022, providing a more comprehensive and engaging representation of the data.

Previous Visualization

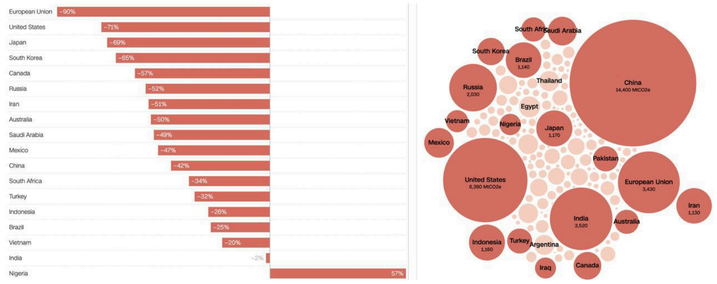

Figure 1: Emissions reduction needed by 2030 for top emitters and 2022 greenhouse gas emissions by country

Strengths

- The dynamic bubble chart emphasizes rankings and visualizes leading countries' emission contributions in 2022, showing metrics and the amount of greenhouse gas emitted, including data for countries outside the top 20 when hovered.
- The bar graph includes future predictions up to 2030 to show estimated CO2 emissions by country, scaled to specific units despite CSS-related visibility issues.
- Different hues of red describe the intensity of the data, providing a clear visual distinction.

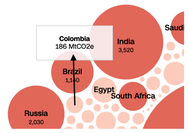

Figure 2: Close-up of bubble chart displaying greenhouse gas emissions by countries outside the top 20, showing metric and emission amount on hover

Suggested Improvements

- *More labels* could be used with the bubble chart and graphs to convey the content more effectively at a glance.
- *Provide a legend* for the bubble chart to show the size of the bubble represents the amount of emissions.
- *Use the choropleth map* to show top 10 emitters of the world and visualize the greenhouse gas emissions per capita globally. This will highlight the emission contributions of leading countries relative to others, making it easier to identify key emitters.
- *Provide a line to map* the country labels to the respective country in the choropleth map.
- *Leverage on a bubble plot* to represent the predicted emission reduction for the top 10 countries on top of the choropleth map, where the bubble sizes distinctly represent the required emission reduction for each country.
- *Use a color palette* to indicate the intensity of each country's emission contribution, providing a clear visual difference.
- *The integration of bubble plot on the choropleth map combines the information from two graphs* into a single comprehensive visualization.

Implementation

Data

The datasets used include per capita greenhouse gas emissions in CO2 equivalents[4], population[5], and projected reductions in total greenhouse gas emissions for 2030[6]. The population data is used to calculate the per capita projected reduction data, which is then used for creating the bubble plot.

Software

We used the Quarto publication framework and the R programming language, along with the following third-party packages:

- *tidyverse* for data transformation and *ggplot2* for visualization.
- *rnaturalearth* for the choropleth map.
- *ggrepel* provides geoms for overlapping text labels.
- *ggtext* for markdown elements.
- *mapview* for checking map features.
- *rmapshaper* for simpler map features.
- *scales* for legend breaks.
- *sf* for geometrical operation purposes.
- *knitr* for dynamic document generation.
- *cowplot* for combining multiple plots into a single visualization.

Improved Visualization

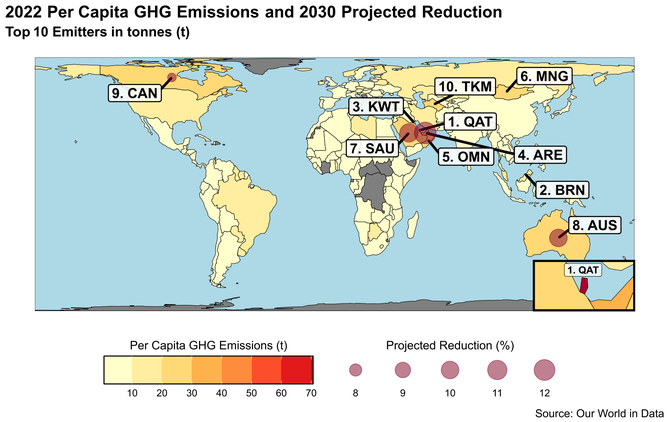

Figure 3: Combined total emission per capital and amount of predicted reduction of greenhouse gases.

Insights

- High Emission Sources: The top emitters are primarily fossil fuel-rich countries like Qatar, Brunei, Kuwait, UAE, Oman, and Saudi Arabia, along with coal-dependent and industrial nations such as Mongolia, Australia, Canada, and Turkmenistan. These countries' high emissions are driven by extensive oil and gas production, coal usage, and energy-intensive industries.[7]
- Projected Reduction: The bubble plot overlay shows the projected emission reduction. However, many countries in the top 10 did not participate in the survey. Consequently, only 3 bubble plots are included to represent the projected reduction of greenhouse gas emissions.
- Skewed Data: The data is skewed towards 70 tonnes due to an outlier, the top emitter, Qatar, while the remaining nine countries fall within the range of 20 to 40 tonnes. This outlier may be attributed to Qatar's emission spike during the World Cup 2022.[8]

Conclusion

We successfully implemented all suggested improvements for the non-interactive visualization. By adding numerical figures, labels, and legends, the revised visualization is more informative. The choropleth map highlights the top 10 emitters and global per capita emissions, making key contributors easy to identify. Lines mapping country labels and emissions enhance clarity, while bubble sizes for predicted reductions and a color palette for emission intensities ensure the visualization is comprehensive and readable.

[1] Jeeven Ravi et al., "Identification of Greenhouse Gases Emission Thorough Exploration of The Emission from Different Sectors" 2020 6th International Conference on Computing Engineering and Design (ICCED), 2020, pp. 1-7

[2] M. Tavassoli et al., "Comparison of effective greenhouse gases and global warming" 2023 8th International Conference on Technology and Energy Management (ICTEM), 2023, pp 1-5

[3] https://edition.cnn.com/interactive/2023/12/us/countries-climate-change-emissions-cop28/

[4] https://ourworldindata.org/grapher/per-capita-ghg-emissions?tab=table

[5] https://data.worldbank.org/indicator/SP.POP.TOTL?end=2022&start=2022&view=bar

[6] https://climateactiontracker.org/cat-data-explorer/country-emissions

[7] https://www.straitstimes.com/world/middle-east/to-meet-climate-goals-gulf-countries-will-have-to-overhaul-everything

[8] https://www.scientificamerican.com/article/the-world-cup-in-qatar-is-a-climate-catastrophe/