Visualizing Greenhouse Gas Emitting Countries (1990-2021)

Ryan Chua, Woon Jun Wei, Ong Si Hui, Chua Kang Le, Phua Tiffany, Loo Siong Yu

SINGAPORE INSTITUTE OF TECHNOLOGY

Introduction

Greenhouse gas (GHG) emissions from human activities such as fossil fuel combustion, deforestation, and industrial processes significantly contribute to climate change. The primary GHGs—carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases—trap heat in the Earth's atmosphere, causing a warming effect known as the greenhouse effect. This results in rising global temperatures, disrupted weather patterns, and more frequent extreme weather events. For instance, global temperatures have increased by approximately 1.2℃ since the late 19th century[1], and sea levels have risen by about 20 centimeters over the past century due to melting polar ice caps and glaciers, threatening various species' habitats. Beyond climate change, GHG emissions affect air quality and public health, leading to respiratory and cardiovascular diseases. The World Health Organization (WHO) estimates that air pollution causes around 3.3 million premature deaths annually[2]. Additionally, the increased concentration of GHGs disrupts ecosystems and endangers biodiversity. Ocean acidification, resulting from excess CO_2 absorption by oceans, has risen by 30% since the Industrial Revolution[3], adversely impacting marine life, particularly coral reefs and shellfish.

Visualizing GHG emissions is essential for understanding their distribution across countries and sectors, identifying major contributors, and informing policy decisions. The top 10 emitting countries—China, the United States, India, Russia, Japan, Germany, Indonesia, European Union (EU), Canada, and Brazil—account for a significant portion of global emissions. Major sectors contributing to these emissions include energy production, transportation, industrial processes, agriculture, and waste management. The energy sector is the largest source due to fossil fuel combustion, while the transportation sector significantly contributes through gasoline and diesel use. Highlighting these contributors underscores the need for coordinated climate action and promotes sustainable practices, renewable energy, and effective policies.

Previous Visualization

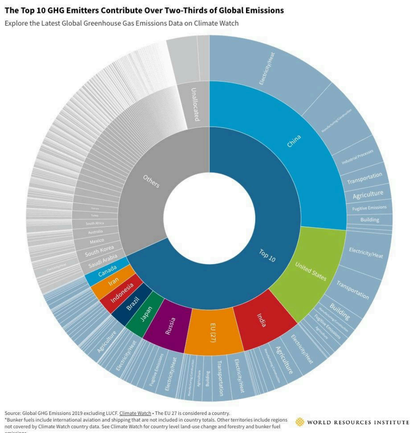

Figure 1: Top 10 Countries with the Highest Greenhouse Gas Emissions by Sector

Strengths

- The visualization effectively ranks countries based on their emissions, providing a clear comparative framework.
- Distinct color coding aids in differentiating between countries, enhancing visual clarity.
- The plot includes contextual information by illustrating the sectors contributing to emissions for each country, enriching the analysis.
- The central focus on the top 10 emitters highlights their significant share of global emissions, emphasizing their impact.
- The use of a donut chart allows for an organized and layered presentation of data, facilitating easier interpretation.

Suggested Improvements

1. *Transitioned to a treemap* from a stacked donut chart to address the clustering of information.
2. Selected five common sectors, *categorizing the remaining* as "Other Sectors," resulting in a clearer visualization and focused comparison of emissions.
3. The treemap illustrates the top 10 countries and their emission sectors, *emphasizing that they contribute two-thirds* of global emissions.
4. *Color-coded legends* were provided for easy sector identification.
5. The remaining 184 countries are *greyed out*, highlighting the top 10 countries.
6. Used Color Brewer's *Accent* for sectors to *enhance visual distinction and comprehension*.
7. Applied *black outer borders* to differentiate countries clearly.
8. Used *white inner borders* to separate sectors distinctly within each country.
9. Included *subtitles and legends* to aid reader understanding of the plot.

Implementation

Data

Data was retrieved from the World Bank Data website[4], encompassing greenhouse gas emissions (CO2, F-Gas, N2O, CH4) by sector for various countries. Negative values were removed to ensure accuracy, and the top 10 countries with the highest emissions were selected for analysis.

Software

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

- *readxl* for data import
- *tidyverse* for data transformation, including *ggplot2* for visualization based on the grammar of graphics
- *knitr* for dynamic document generation
- *gt* for creating tables
- *wbstats* for retrieving data from the World Bank Data API
- *dplyr* for data manipulation
- *treemapify* for creating treemaps

Improved Visualization

Figure 2: Revised Visualization of Top 10 Countries with the Highest Greenhouse Gas Emissions by Sector

Further Suggestions for Interactivity

To enhance user engagement and provide deeper insights, we recommend incorporating interactive features into the treemap visualization. Specifically, these features will enable users to explore emissions data more effectively. Interactive elements could include hover information to display detailed emissions data, including sector and country specifics, and percentage of world emissions. Additionally, filtering options will allow users to focus on specific countries, sectors, or emission types, with elements highlighted on hover to emphasize selected data. Clickable elements could be implemented to allow users to select the same sectors in other countries for size comparison, significantly improving the usability and informational depth of the visualization.

Conclusion

We have refined the visualization of the top 10 countries with the highest greenhouse gas emissions that contributes two-third of the global emissions. By using a treemap, we have provided a non-clustered and clearer visualization without swaying away from the message of the original visualization. By picking the 5 common sectors and categorizing the remaing as one, contributes to a non-clustered visualization. Color-coded legends are provided for easy identification of sectors. The remaining 184 countries are greyed out to emphasize that the top 10 countries contributed two-third of the global emissions. To enhance user engagement and facilitate data exploration, we recommend integrating interactive features. To end it off, visualizing greenhouse gas emissions plays a crucial role in raising awareness about climate change, advocating for sustainable practices, and informing policy decisions aimed at mitigating environmental impacts caused by human activities.

[1]Jones, P. D., New, M., Parker, D. E., Martin, S., & Rigor, I. G. (1999). Surface air temperature and its changes over the past 150 years. Reviews of Geophysics, 37(2), 173–199. doi:10.1029/1999rg900002

[2]Lelieveld, J., Evans, J., Fnais, M. et al. The contribution of outdoor air pollution sources to premature mortality on a global scale. Nature 525, 367–371 (2015). https://doi.org/10.1038/nature15371

[3]Popattanachai, N., & A Kirk, E. (2021). "Chapter 4: Ocean acidification and multilateral environmental agreements". In Research Handbook on Ocean Acidification Law and Policy. Cheltenham, UK: Edward Elgar Publishing. Retrieved Jun 14, 2024, from https://doi.org/10.4337/9781789900149.00012

[4]https://www.climatewatchdata.org/ghg-emissions?end_year=2021&start_year=1990