The Evolution of CO2 Emissions Through the Years

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1 MOTIVATION

Carbon emissions from food production and travel have become significant contributors to overall carbon footprints. The production and transportation of food contribute to emissions through agricultural practices, deforestation, and long-distance supply chains.

Similarly, travel-related emissions arise from transportation modes such as cars, airplanes, and ships. Reducing carbon emissions in these areas is crucial for mitigating climate change.

Embracing sustainable agriculture practices, promoting local and seasonal food, reducing food waste, and opting for eco-friendly transportation alternatives can help minimize the carbon footprint associated with food products and travel, leading to a more sustainable future.

In this project, we have selected a dataset with data containing the CO2 emissions per country throughout the years 1980 - 2021. Additionally, the data also contains CO2 emissions for different food types and modes of transport.

Our goal is to visualize this data to see the variations in CO2 emissions around the globe and also provide a personalized CO2 emissions calculator for individuals to assess their own contributions to CO2 emissions and see which factors play a significant role.

2 FROM IDEA TO PRODUCT

2.1 Introduction

In this project, we have developed a visualization of carbon emissions for countries from 1980 to 2021. The visualization provides a clear representation of the increasing levels of carbon emissions across different countries over the years. In addition, the user can visually see, through a color gradient, the carbon emission of each country for any year between 1980 to 2021. This allows citizens to gain awareness of the historical and current state of carbon emissions in various countries.

Furthermore, our project offers a practical tool for individuals to calculate the carbon emissions associated with the food products they consume, the transportation modes they use, and the amount of energy they utilize. The tool provides a detailed breakdown of carbon emissions for specific food items and transportation methods, along with an overall cumulative sum. By using this tool, individuals can gain insights into the carbon footprint generated by their daily choices, enabling them to make more informed decisions and potentially reduce their personal carbon emissions.

2.2 Initial Research And Data Collection

During the initial research phase, we explored different reliable and up-to-date datasets on carbon emissions, focusing on the factors influencing emissions, such as energy production, transportation, and food consumption.

Finally, we used a dataset from the ourworldindata.org website. The data is available in CSV format, therefore easy to parse, and provided us with all the information we would require. For example, the website has articles analyzing the greenhouse gas emissions of food products [2], transport [3], or the energy mix of individual countries [1]. Additionally, all the data is sourced from peer-reviewed conference papers and government reports.

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2.3 Prototyping

For milestone-2, we initiated the prototyping phase by sketching visualization layouts and interactions. As shown in Figure 1, we provided the sketch that depicts one part of the website where a user can calculate the carbon emission of the food they consume or the transport they use.

For the food category, the user would enter all the food items, their quantity, and the period of consumption, and then the website computes and visualizes the carbon emissions. For the transport category, the user enters the mode of transport, duration of travel, and distance of travel to visually learn about the carbon emission from the transport.

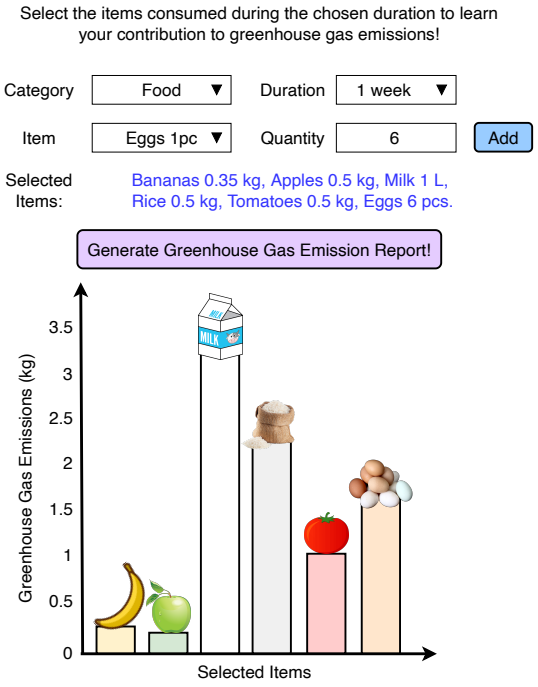

Fig. 1. Sketch-1 for personlised calculator.

The other part of the website that we presented for milestone-2 visualized the energy use per country from 1980 to 2021.

Visualization works with two modes, one is per country, in which the user hovers the mouse over the country in which they are interested, and then a pop-up box displays energy use over the years. Another mode is where the energy consumption of all the countries is displayed together using a heat map. We showed the first mode with the sketch as shown in Figure 2.

2.4 Development

Using web development tools such as HTML, CSS, and JavaScript, we implemented the visualization and data processing functionalities. We leveraged D3.js, a JavaScript library for data visualization, to create interactive and dynamic charts,

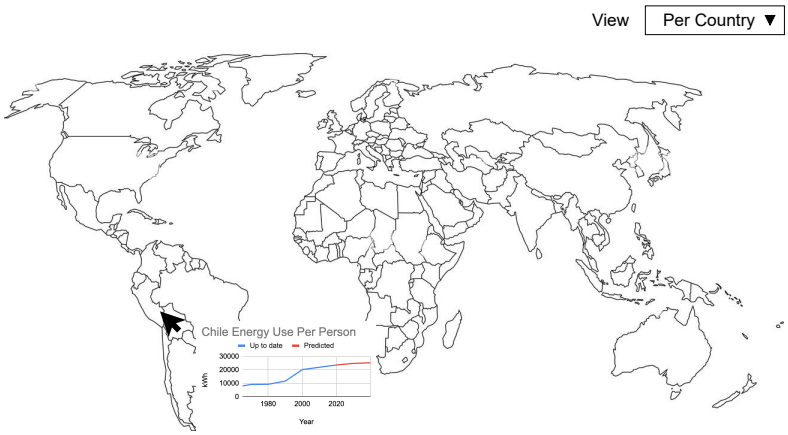

Fig. 2. Sketch-2 for country wise emissions.

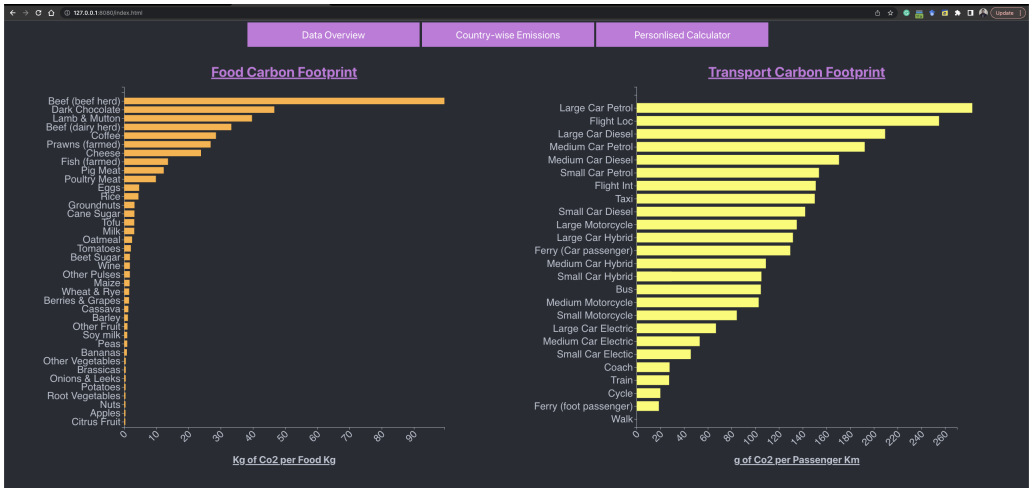

Fig. 3. The data overview section of the website.

maps, and graphs. We also incorporated a user-friendly interface for individuals to input their food and transport choices. The website has three tabs for three different visualizations.

2.4.1 Data Overview. In this section of the website, users can access a visually engaging and informative analysis of carbon emissions related to different foods and modes of transportation. The aim is to provide users with a comprehensive understanding of the environmental impact associated with their choices.

To facilitate easy comprehension, the analysis employs bar charts, which effectively illustrate and compare the carbon emissions across various categories. These charts allow users to identify at a glance the stark differences in carbon emissions between different food products and modes of transportation.

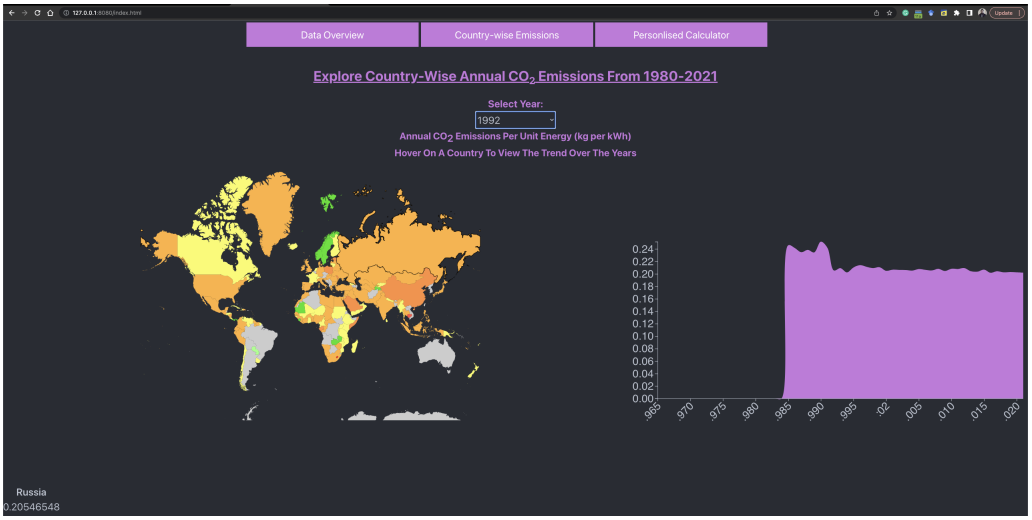

Fig. 4. The country-wise emissions section of the website.

2.4.2 Country-wise Emissions. In this section of the website, users have the opportunity to explore and visualize carbon emissions data for different countries across the years 1980 to 2021. The website provides an intuitive interface where users can select a specific year of interest and get a global perspective. Once a year is selected, the website displays a heat map overlaying the world map. This heat map effectively highlights countries with high carbon emissions for the chosen year. By visually representing the data in this way, users can quickly identify regions that contribute significantly to global carbon emissions.

Furthermore, the website offers an additional feature for users interested in the carbon emissions of a specific country. By simply hovering the mouse cursor over a particular country on the heat map, users can access detailed information on that country's carbon emissions from 1980 to 2021. This interactive feature enables users to observe the trends and changes in emissions for a specific country over time.

To enhance the visual appeal, we implemented an animation for the line graph showcasing carbon emissions over the years. The animation creates an effect as if water is falling from the top and lands on the line graph, resulting in a seamless representation of the fluctuating carbon emission patterns, resembling a smooth wave, as shown in Figure 5.

2.4.3 Personlised Calculator. Once users have a clear understanding of the carbon emissions associated with different food products, modes of transportation, and the past and current emissions of their own country, they can take action to calculate and reduce their personal carbon footprint. This website provides valuable tools and features to facilitate this process, empowering individuals to make more sustainable choices in their daily lives.

One prominent feature is the annual calculator section. Here, users can input their location, mode of transportation, distance traveled, and the type of fuel used by their chosen mode of transport. By providing these details, users can accurately calculate the carbon emissions resulting from their travel habits. Additionally, users can enter the consumption amounts, measured in grams per week, for various food products such as beef, dark chocolate, coffee, prawns, eggs, rice, oatmeal, and more. This input allows the website to calculate the carbon emissions associated with

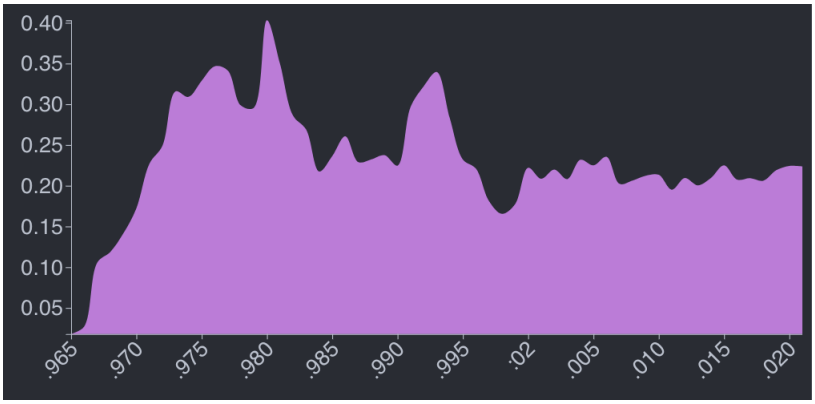

Fig. 5. Line Chart.

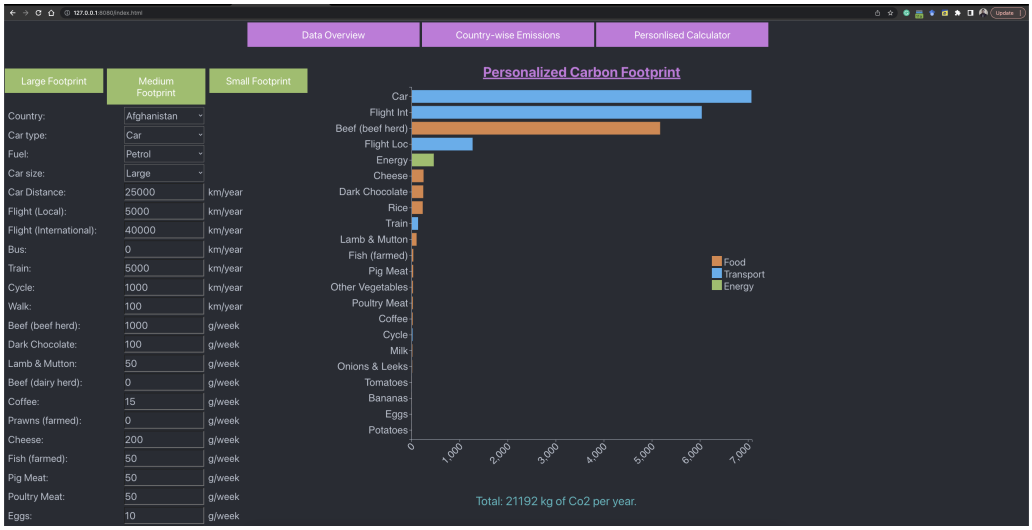

Fig. 6. The personlised calculator section of the website.

each food product per year. Furthermore, the website provides a cumulative sum of all the food products and travel, giving users a comprehensive overview of their total carbon emissions.

Armed with this information, users can make more informed choices about their food consumption and mode of transportation. By calculating the carbon emissions associated with different options, individuals can plan their lifestyles in a way that minimizes their environmental impact. Whether it's opting for more sustainable food choices or choosing greener modes of transportation, users have the opportunity to make a positive difference.

2.5 Final Product

The final website with the visualizations can be run by cloning the git repository, and inside the website directory, run the server by typing:

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$ node server.js
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Then, in any browser on a desktop (avoid laptops because of small screen) open http://127.0.0.1:8080/index.html

A video of the website with live visualizations can be found here: https://drive.google.com/file/d/1USOU8rOLBywW1Z5txKoHT-F1etVhC6Vd/view?usp=sharing

2.6 Challenges and Design Decisions

We faced multiple challenges in bringing up this website to create awareness about CO2 emissions and influence lifestyle changes that can create a more sustainable future.

One of the major challenges was to capture the variations in CO2 emissions across the globe. The important aspect here being the color palette for the world map which can clearly show which countries are contributing the most (and the least) to CO2 emissions each year.

Another challenge was to figure out how to represent the variety of activities that we perform in our daily life that contribute to our personalised CO2 emissions. Specifically, the challenge was to visually represent the biggest contributors.

We now elaborate on both of these challenges.

2.7 World Map Color Palette

An important aspect to interactive visualization is to communicate the data in an easily perceivable form. However, this can be challenging depending on the nature of the data in which the lowest and highest data points can vastly differ - but the majority of data points can lie in a much smaller data range. We show the design decisions we came across throughout this experience in Figure 7. As shown in Figure 7a, using a linear scale to represent such a skewed dataset ends up with using a single color on the entire map, failing to provide the important insights hidden in the data. Figures 7b and 7c show our shift towards using thresholds to deploy the color scheme - representing the variations between using uniform intervals vs. tailored intervals. An important lesson learned here is that performing visualization of some data can be challenging without having knowledge about the data. Finally, Figure 7d shows the final scheme we ended up using where a dark background provides contrast and we use an improvised traffic light color scheme - green showing lowest CO2 emissions, yellow, orange and red - showing increased CO2 emissions in order.

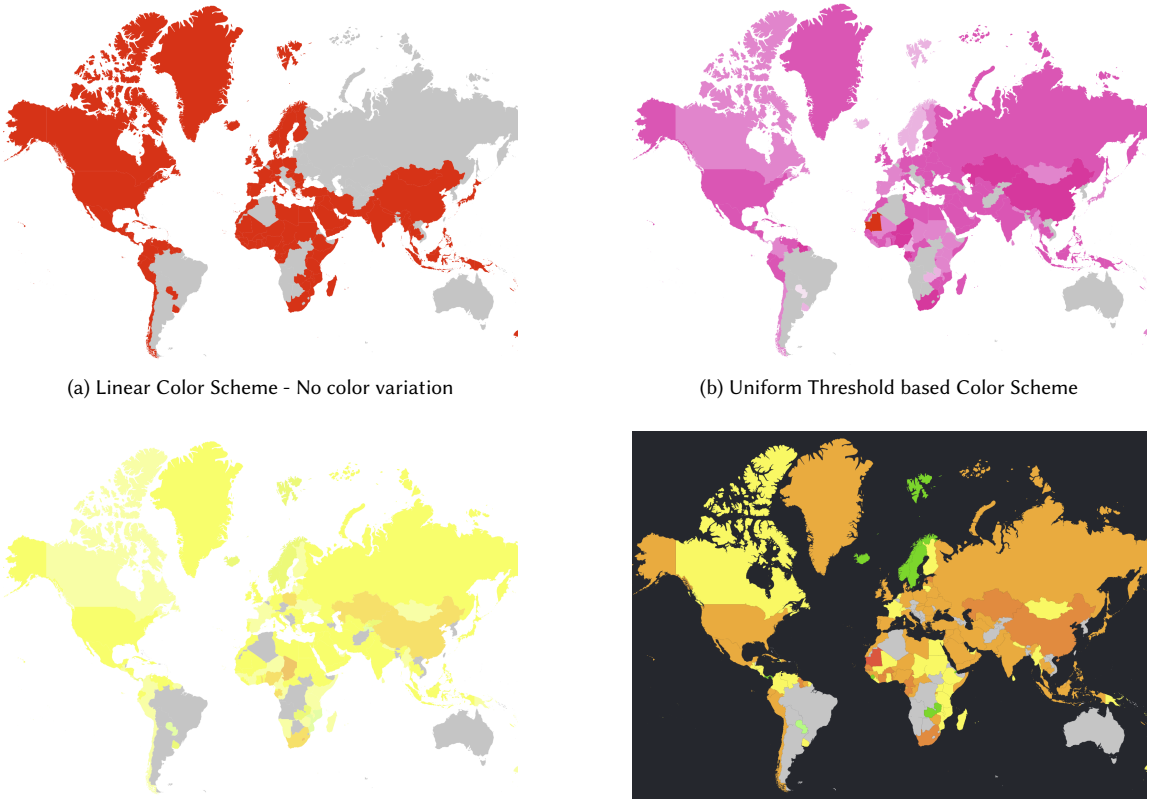
2.8 Visually representing each item in the data

In Milestone 2, we decided to add pictorial representations of each item contributing to CO2 emissions in the personalised calculator. We realised that it was a far-fetched goal for us - given this data can keep changing to add new items on the go - and such a maintenance could be manual effort.

3 FUTURE SCOPE

3.1 Visualise the biggest contributors to CO2 emissions

As described in the previous section, we would in the future like to add pictorial representations of each item contributing to CO2 emissions in the bar charts. An ideal version would contain an API where we can request from a large set of clip-arts in png format.



(a) Linear Color Scheme - No color variation

(b) Uniform Threshold based Color Scheme

(c) Tailored Threshold based Color Scheme

(d) Improving Color Range

Fig. 7. Attempts at selecting an appropriate color scheme for the world map

3.2 Add recommendations to reduce per person CO2 footprint

The goal of this project can be raised to include a personalised recommendation scheme so that people as individuals can start taking action to reduce their annual CO2 footprints. In this regard, we propose that the following items can be effective, while trying to propose effective improvements that do not affect the individual's quality of life.

- Recommend food items which hold the same nutritional values while emit significantly lower CO2.
- Recommend transport modes that provide several options to balance the CO2 emissions and the time taken during transport. E.g. Travelling 2 kms by car can be done in 5-7 minutes, whereas walking walking the distance can take 38-40 minutes. While biking provides a balance between the two and covers the distance in 13-14 minutes, and another option is public transport which takes 21-22 minutes. Depending on the time to spare, the distance to cover, and the physical health of the individual, recommendations can vary.

4 BREAKDOWN AMONGST TEAM MEMBERS

For this milestone, the team members collaborated and contributed to different aspects of the project. We divided the project into two parts: CO2 emissions at the country level and carbon emissions at the individual level. Neelu

and Shashwat worked together on the first part - which involved creating the interactive world map, visualising the per country data and performing the necessary data pre-processing. Louis took charge of deploying the second part, ensuring a seamless user experience. Additionally, Louis was responsible for the initial website setup during Milestone 2, while Neelu played a crucial role in ideating visualizations that effectively conveyed the data. Shashwat led the report writing and video creation process, with Neelu and Louis providing valuable assistance throughout, and Neelu describing the challenges and the future scope. The team members discussed and revised the styling and color schemes of the website together. The combined efforts of all team members resulted in the successful completion of the project, with each member contributing equally to its overall outcome. Overall, for us three, it was a well-organized and constructive teamwork experience.

5 CONCLUSION

This project provided valuable insights into the complexities of carbon emissions and individual impact. We successfully created a visualization that raises awareness about environmental issues and empowers individuals to make informed choices. The project highlighted the importance of accessible and engaging visualizations in promoting sustainable behavior.

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