R2 Report

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1 Phase 1: Project Initiation

The project "Visualizing Climate Change Dynamics: Insights for Informed Decision-Making" was chosen due to the critical significance of climate change as a global challenge. Climate change impacts various aspects of society, including ecosystems, economies, and social structures, necessitating informed decision-making to mitigate its effects. By harnessing the power of data visualization, this project seeks to illuminate key factors influenced by climate change, such as energy usage, fossil fuel prices, emissions, and economic ramifications. Through visual representation of complex data sets, stakeholders can gain clarity on the interconnected dynamics shaping our energy landscape and understand the potential GDP losses from climate risks, as well as the benefits derived from avoiding climate damages. This approach not only aids in understanding the multifaceted nature of climate change but also equips stakeholders with actionable insights to guide decision-making processes and facilitate substantial progress in addressing this global challenge.

We planned the following deliverables with respect to the topic chose:

- Compilation and documentation of relevant datasets on climate change, energy usage, economic indicators, and disaster occurrences in India.
- Development of methodologies for analyzing trends, impacts, long-term variability, and correlations within the datasets.
- Design and creation of initial visualizations, including line charts, area plots, bar charts, scatter plots, and correlation matrices.
- Production of detailed documentation outlining project goals, methodologies, and initial findings.
- Establishment of a solid foundation for deeper analysis and stakeholder engagement in subsequent phases.

2 Phase 2: Implementation and Analysis

After recieving feedback from the teaching assistant and the professor we had to make a few modifications in the decided deliverables. This is a brief summary of what we have done for R2 of data visualisation project - "Visualizing Climate Change Dynamics: Insights for Informed Decision-Making"

- Video simulation of rise in global sea level from 1880-2014
- Co2 Emissions for a particular country over the years from 1800-2022
- A Heatmap Times-series of Co2 Emissions over the globe from 1800-2022
- A visualisation of Global surface temperature change comparing with amount of ice in sea from 1978-2019.
- A visualisation of Rainfall and Temperature of India over the years from 1901-2020

NOTE:- We have elaborated on the dataset,visual encodings, navigation, animation, colors , etc that were used in our visualisations in this section.

2.1 Video simulation of rise in global sea level from 1880-2014

The datasets we have used for this visualization are in the project folder: `sea_level_data.csv` for visualising the mean sea level changes across the years. For a year we have decided to take the GMSL(Global Mean Sea Level) of the 6th month(June) to reflect the sea level for a year since visualising for every month of years from 1880-2014 would be lengthy and frustrating for the viewer to see. We have decided to take the GMSL of 1880-06-15 to be base zero reference for our visualisation and every other year's GMSL to be taken with reference to GMSL of 1880.

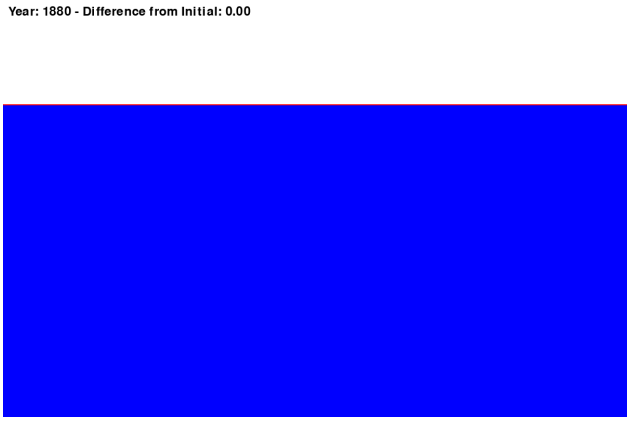


Figure 1: Water level at 1880 - Taken to be reference level zero

Here we have generated frames which is a snapshot of sea level at a particular year. We have combined the frames pertaining to years 1880 all the way to 2014. Our plan involved creating a visually engaging video simulation to illustrate the gradual increase in sea levels over the years using time series visualization. We aim to depict the impact of this rise in a clear and understandable way. By using animation and other visual aids, we want to show how sea levels have been rising steadily over time and how it affects coastal areas and communities.

2.2 Co2 Emissions for a particular country over the years from 1800-2022

The dataset we have used is in the project folder as `data.csv` for visualising the Co2 emissions for a particular country over the years from 1800-2022.

We have used the values under the columns under 1800-2022 for every country as referenced by its country code(ISO3)in the dataset, and took the rows corresponding to entity KYOTOGHG(AR4GWP100) and category (IPCC2006-PRIMAP) 1.A corresponding to unit CO2 gigagram/a.

For this **line chart**, users are provided with a **dropdown menu** offering the choice of selecting any country from around the world, as well as the option to view data for the entire planet. Upon selection, the corresponding line chart is displayed. When hovering over a point on the line, users can observe the corresponding year and CO2 emission values. Furthermore, **zooming and brushing** functionalities have been incorporated to allow users to delve deeper into the data and analyze specific trends.

With this plot, users can easily track the increase in CO2 emission levels for a country of their choosing. By observing the rising trend, they can better understand the significant threat that CO2 emissions pose to global warming.

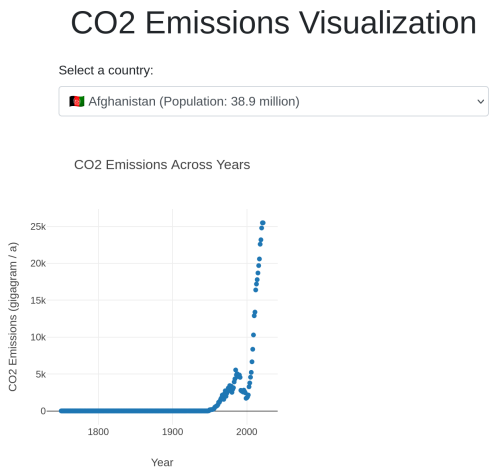


Figure 2: Example line plot

2.3 A Heatmap Times-series of Co2 Emissions over the globe from 1800-2022

The dataset we have used is in the project folder as `data.csv` for visualising the Heatmap Time-series of Co2 emissions over the globe from 1800-2022.

The dataset we have used here for this visualisation is identically the same used for the previous visualisation with the same columns and rows used for visualisation purpose.

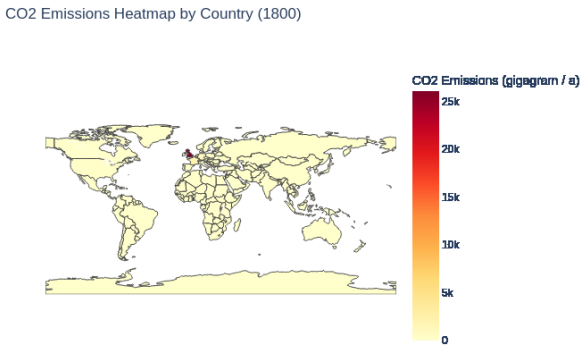


Figure 3: Heatmap snapshot of C02 emissions over the globe for the year 1800 - Color

Using this visualisation, one can compare the co2 emissions country wise under the same visualisation. This **heatmap** makes it easier to make comparisons across different countries and their rates of C02 emissions over the years which was **not possible in the previous visualisation** of the line-chart. for the colour coding we have used different **shades of red,yellow and orange** that mainly correspond to the word 'heat'.

2.4 A visualisation of Global surface temperature change comparing with amount of ice in sea from 1978-2019.

The datasets we have used for this visualisation is in the project folder-`seaice.csv` and `GlobalTemperature.csv`. The attributes we have used from the `seaice.csv` are Year and Extent. We have calculated the mean Extent for a year and mapped it to the corresponding year. Similarly, the attributes we have used from

`GlobalTemperature.csv` are dt and LandAverageTemperature. From these two columns, we have extracted the year and calculated the mean LandAverageTemperature and mapped it to the corresponding year.

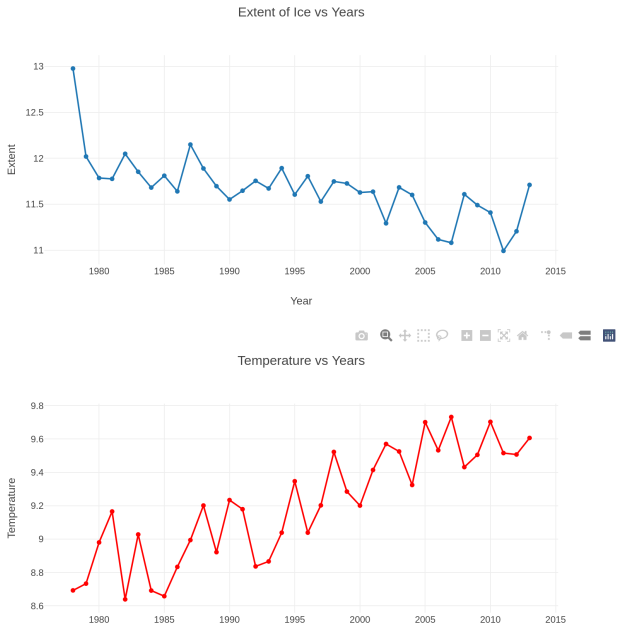


Figure 4: The Plots showing extent of Ice vs Year and Average Surface temperature vs Year

Line charts are particularly suitable for visualizing continuous data over a continuous time interval, making them ideal for illustrating trends and patterns in time-series data. In the line chart visualization, the extent of **sea ice is represented by blue lines**, while the **land average temperature is depicted by red lines**, each on separate graphs. The **tooltip feature** has been implemented, allowing users to hover over data points to view the values of temperature or sea ice extent for a particular year. Additionally, **zooming and brushing functionalities** have been incorporated, enabling users to zoom in on specific areas of interest and brush over sections to analyze them more closely.
These line-charts can advocate the effect of climate change on the increase of average surface temperature of earth which in turn leads to the melting of ice glaciers in the seas leading to a rise of sea levels leading to flooding and submerging of coastal areas near the sea.

2.5 A visualization of Rainfall and Temperature of India over the years from 1901-2020

The datasets we have used for this visualization are in the project folder: `TEMP_ANNUAL_SEASONAL_MEAN.csv` and `RF_AI_1901-2021.CSV`. We have used all the attributes and rows of both datasets for this visualization.

We developed **area charts** to represent data for each quarter of the year, with **distinct color encoding** for every quarter. Area charts are typically used to represent cumulative data and show trends over time while emphasizing the magnitude of change. This color differentiation aids in visually distinguishing between different quarters and their corresponding data. Users can effortlessly **zoom in and brush** through the charts to explore intricate details further. Additionally, users have the **flexibility to select any number of quarters** by choosing colors from the provided color palette on the right-hand side and observe the corresponding changes in the graph. Users can **compare temperature and rainfall trends** across the entire time span, offering insights into long-term climatic patterns particular to India.

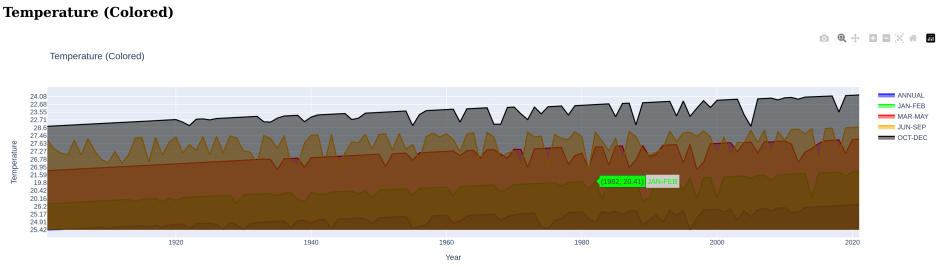


Figure 5: Plot showing temperature of India averaged for every consecutive three months and annually over the years

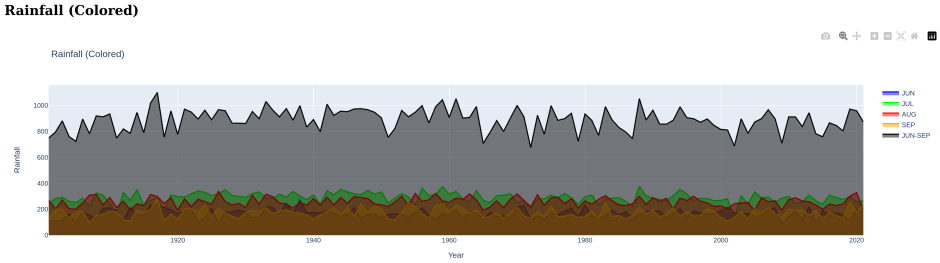
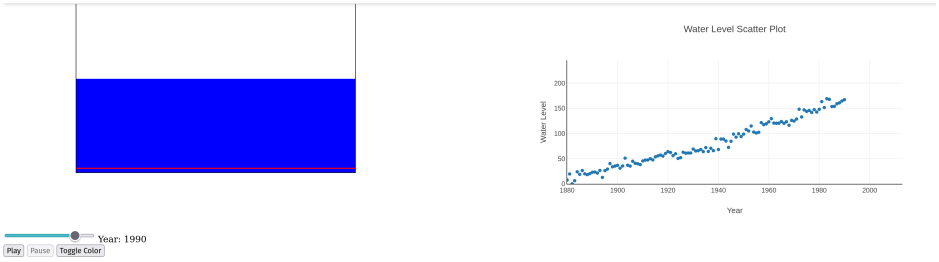


Figure 6: Plot showing rainfall of India averaged for every consecutive three months and annually over the years

3 Phase 3: Refinement

After our mid-evaluation, we received a few remarks about the visualizations that we had created until phase 2. We have improved our visualizations in this phase and worked on the layout and functionalities of the website.

3.1 Video simulation of rise in global sea level from 1880-2014

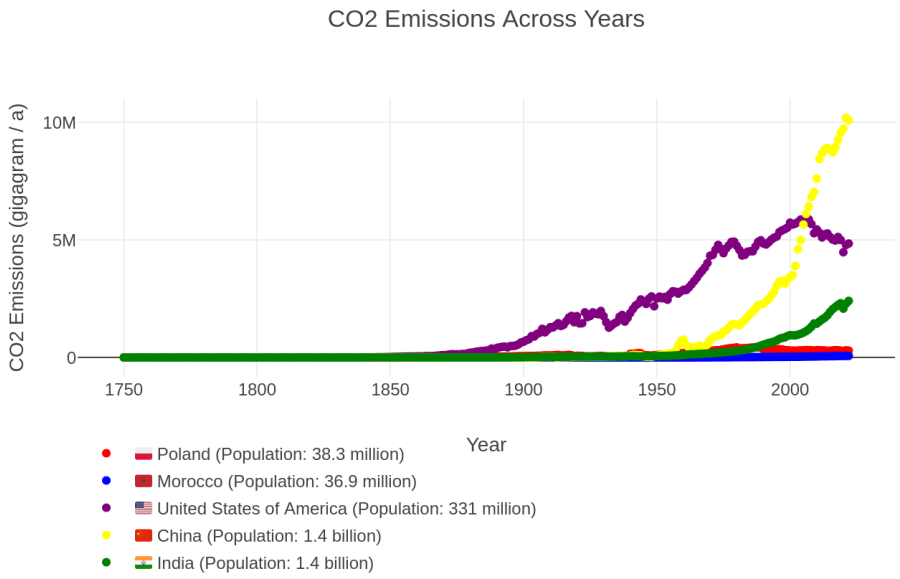


One of the refinements we made to this video simulation from phase 2 was that we added a line chart which displays the growth of sea level parallely over time and also added user interactivity in the sense that a user can choose to view the sea level for their year of choice by dragging the slider button.
Rest of the details remain the same as that of Phase 2.

3.1.1 Limitations:

The water level scatter plot visualization, while displaying the overall increasing trend in global sea levels over time, suffers from several limitations that restrict its usefulness and applicability for informed decision-making. Crucially, it lacks geographic specificity, failing to capture regional or local variations in sea level rise influenced by factors like ocean currents, coastal geography, and land movements.

3.2 Co2 Emissions for a particular country over the years from 1800-2022

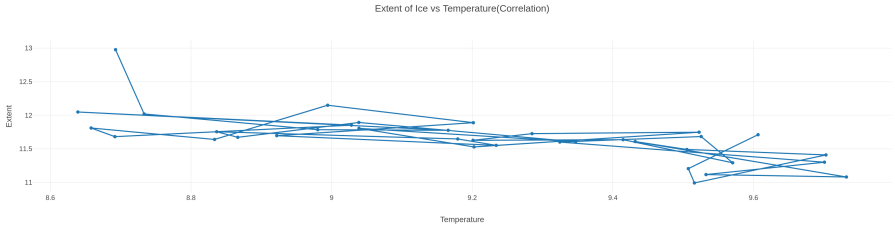


The refinements we made to this visualisation from phase 2 is that we have employed user interactivity to compare between different countries (max of 5) on the same chart which was not possible in the earlier version which could only have one country's Co2 emission details at a time. Rest of the visualisation details remain the same.

3.2.1 Limitations:

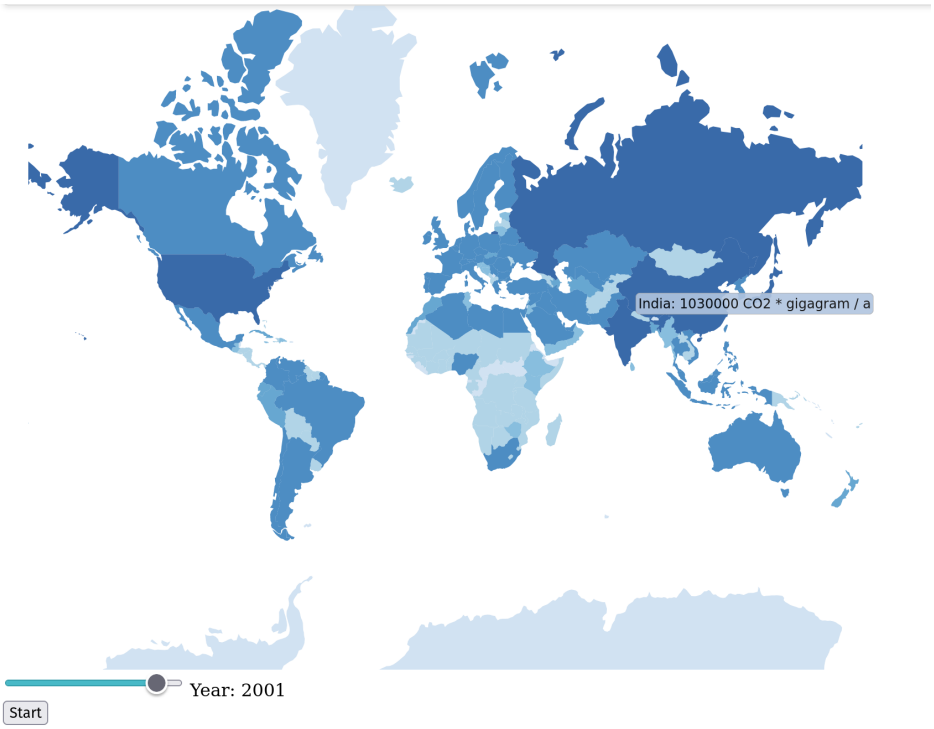
The CO2 emissions across years visualization, while effectively illustrating the historical emission trajectories of different countries over time, suffers from several limitations that restrict its analytical utility and applicability. Notably, it lacks a sectoral breakdown of emissions, hampering the identification of major contributing factors and potential areas for reduction strategies. Additionally, the absence of per capita or GDP normalization makes it challenging to directly compare emissions intensity or efficiency across countries with varying population sizes and economic scales.

3.3 A visualisation of Global surface temperature change comparing with amount of ice in sea from 1978-2019



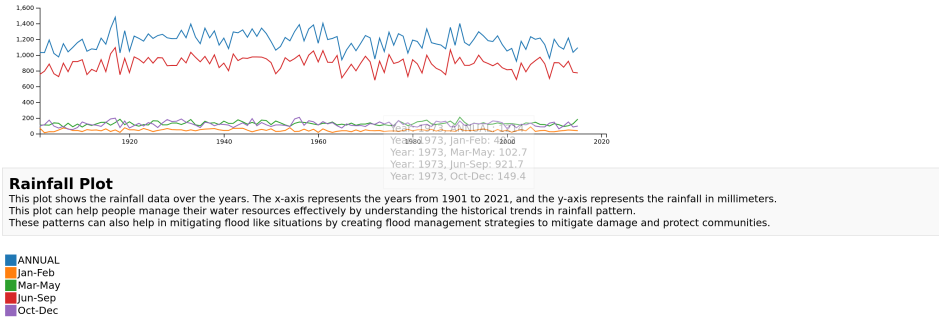
We added a correlation graph between Temperature and Amount of ice showing the exact relationship between the two variables which was not possible in our earlier release.

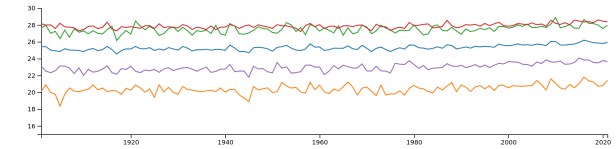
3.4 A Heatmap Times-series of Co2 Emissions over the globe from 1800-2022



Our earlier version was critiqued due to its lack of user interactivity in the creating the animation. So we decided to give user control to choose the year with the help of a slider in which he can see the C02 emissions for a country by just hovering on it. These interactivity features were implemented in the final phase. Rest of the details remain the same.

3.5 A visualization of Rainfall and Temperature of India over the years from 1901-2020





Temperature Plot
This plot shows the temperature data over the years. The x-axis represents the years from 1901 to 2021, and the y-axis represents the temperature in degrees Celsius.
This plot can help people understand climate trends particularly in terms of temperature.
Analyzing temperature data over time can provide insights into long-term climate trends, helping researchers and policymakers understand patterns such as global warming or cooling

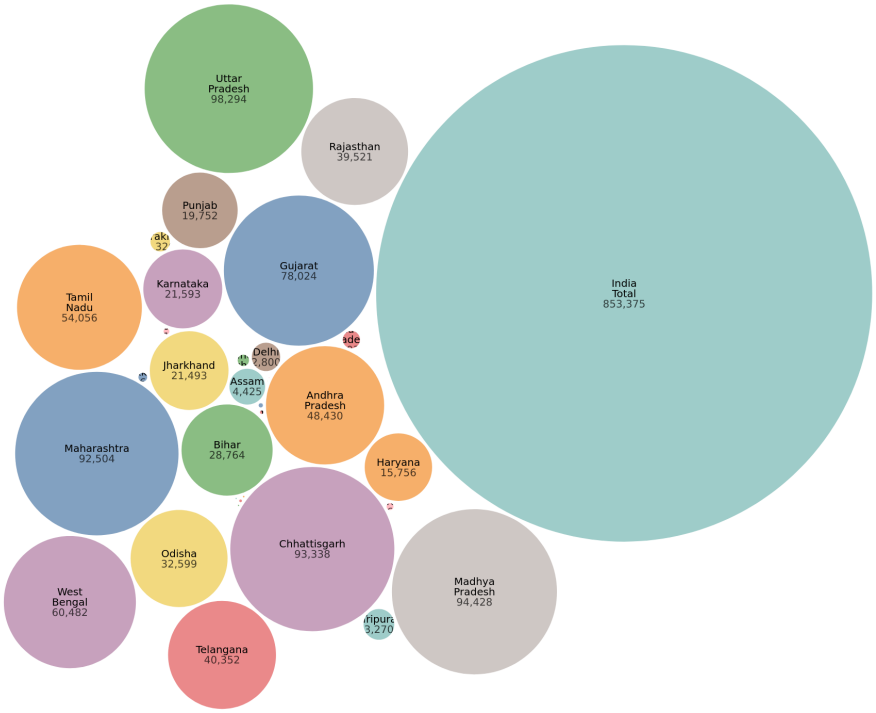
ANNUAL
JAN-FEB
MAR-MAY
JUN-SEP
OCT-DEC

Instead of developing area charts to depict data for each quarter of the year, with distinct color encoding for every quarter, we opted for line charts. Line charts are chosen for their ability to represent trends over time with clarity and readability. Each time period is represented by a different color, ensuring visual distinction without cluttering the graph. Users can easily navigate through the charts by zooming in and out to explore details. This approach allows for better readability and avoids visual clutter while enabling users to compare temperature and rainfall trends across the entire time span, providing insights into long-term climatic patterns specific to India. We have used the same dataset of the area-charts we have made earler.

3.5.1 Limitations:

The rainfall and temperature plot visualization, while useful for understanding historical rainfall and temperature patterns and trends over time, has several limitations that restrict its analytical capabilities. It cannot provide insights into the spatial distribution of rainfall and temperature within the area of interest or reveal the causal factors influencing the observed patterns. Furthermore, the rainfall visualization does not allow for direct comparison or correlation of rainfall patterns with other relevant variables, such as temperature or humidity, which could provide a more comprehensive understanding of water resource management or flood mitigation strategies.

3.6 GHG Emissions throughout the states of India

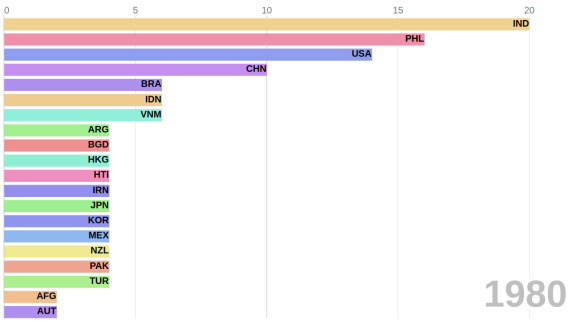


We created a **packed bubble chart** to visualize greenhouse gas (GHG) emissions across different states in India, including an aggregated view for the entire country. The packed bubble chart offers a convenient way to compare emissions between states without the need to examine individual values closely. Additionally, this visualization provides a quick overview of the relative magnitude of emissions across states, facilitating easy identification of high-emission regions. Moreover, the packed bubble chart allows for the simultaneous representation of multiple variables, enabling users to explore additional dimensions of the data, such as emissions by sector or changes over time, enhancing the depth of analysis. We have used the dataset from https://ember-climate.org/data-catalogue/india-electricity-data/ where we preprocessed the csv file only for the total GHG distribution of all the states and UT for the years from 2019 to 2023.

3.6.1 Limitations:

The bubble chart visualization, while effective in presenting the relative greenhouse gas emission levels across different states in India, suffers from several limitations that restrict its analytical capabilities. Firstly, it does not account for emission intensity, which considers emissions relative to economic output or population, potentially leading to unfair comparisons across states with varying sizes or economic activities Finally, the visualization focuses solely on greenhouse gas emissions and does not allow for direct comparison or correlation with other relevant environmental, economic, or social indicators, limiting a comprehensive understanding of sustainability challenges.

3.7 Showing Natural Disasters due to climate Change

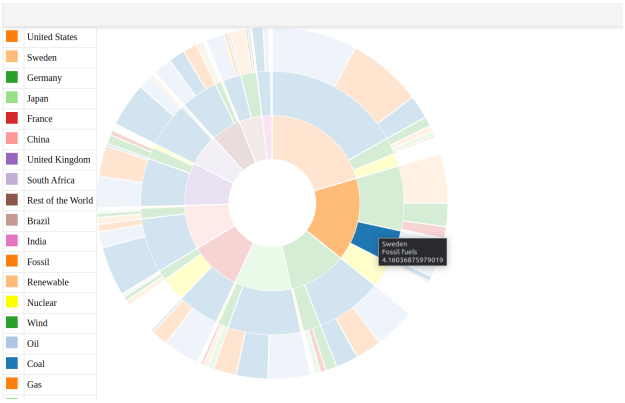


We created a **horizontal bar chart** to visualize Natural disasters across different countries of the world. The horizontal bar chart also incorporates a race animation to show that which country has the highest number accurately.

3.7.1 Limitations:

The horizontal bar chart visualization, while effective in presenting the top countries affected by climate change but does not account to the distribution of the countries affected by it. It does not account for the damage done by the natural disaster.

3.8 Showing Reliance on different sources of fuel



We created a **sunburst chart** to visualize the reliance on different sources of fuel by the world and particularly major countries and through this we can judge their attempts to shift to a cleaner form of energy.

3.8.1 Limitations:

The sunburst chart, while effective in presenting the reliance on different sources of fuel by the world and particularly major countries but cannot show the average emission caused by these countries or does not show the emission for all the countries.

3.9 Users of the visualisations

- **Policymakers and government officials**: Require data to formulate effective climate policies and regulations, and to monitor national and global trends in CO2 emissions and climate variables.

- **Researchers and Climate scientists**: Analyze data to study climate change trends, assess the effectiveness of interventions, and contribute to scientific understanding of climate-related phenomena.
- **Disaster management authorities**: Use climate data to assess climate-related risks, plan for disaster preparedness and response, and develop strategies to mitigate the impacts of extreme weather events.
- **Agricultural sector**: Utilize climate data to make informed decisions about crop selection, irrigation, and timing of planting and harvesting, based on historical climate patterns and trends.
- **Global environmental organizations**: Require comprehensive data to monitor global trends in CO2 emissions, sea ice extent, and surface temperature changes, and to advocate for international cooperation on climate change mitigation efforts.
- **Individuals interested in climate change and its impacts**: Seek access to reliable climate data to understand the causes and consequences of climate change, and to take informed action to address climate-related challenges at the local and global levels.

3.10 Contribution

All three teammates had an equal share of work in both technical and non-technical aspects of the project. Each teammate had done their share of collecting the relevant datasets for each visualisation and making the visualisation.