

# CECS 450 Final Project

## Climate Change: A Visual Change Through Climate Change

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**Abstract**—This project focuses on visualizing global CO2 emissions data to provide insights into trends, patterns, and the impact of human activities on climate change. Through interactive data visualization techniques, we aim to offer a comprehensive view of CO2 emissions over time, with a focus on their consequences for communities and the environment.

### I. INTRODUCTION

This project centers on visualizing the expansive realm of climate change, encompassing various facets, including CO2 emissions as a pivotal component. Our goal is to reveal the intricate tapestry of climate dynamics by incorporating visualizations not only of global CO2 emissions but also of the broader spectrum of environmental alterations. This encompasses shifts in temperature anomalies, changes in weather patterns such as droughts, storms, sea-level fluctuations, and alterations in crop yields. Through interactive visual techniques, our endeavor is to illuminate the interconnected-ness of these factors, offering a comprehensive portrayal of the evolving landscape of climate change.

### II. HOW WE HANDLED OUR DATA

#### A. Data Gather

Global Carbon Atlas is the climate change resource center: Provides CO2 emissions data by country and industry (Lu, 2023). The article covers worldwide CO2 emissions per capita (metric tons) from 2021 to the future (e.g. 2050,2070). Our World in Data: Offers a wide range of environmental data including CO2 emissions (Ritchie, Roser, and Rosado, 2020). Carbon Brief: Global CO2 emissions could peak as soon as 2023, IEA data reveals (Evans and Viisainen, 2023). IMF: World Needs More Policy Ambition, Private Funds, and Innovation to Meet Climate Goals (Black, Jaumotte, and Ananthakrishnan, 2023). Data about global CO2 emissions from fossil fuels, land use change, region, annual emission, per capita per country, emission change over time. Each data has its data record from 1750 to 2022 according to each country saves in a CVS data. Collecting many data, then sorting them into different categories that are similar for comparison. For example, shows a graph to compare each country usage of CO2 emission.

	Entity	Code	Year	Annual CO <sub>2</sub> emissions (per capita)
0	Afghanistan	AFG	1949	0.001992
1	Afghanistan	AFG	1950	0.011266
2	Afghanistan	AFG	1951	0.012098
3	Afghanistan	AFG	1952	0.011946
4	Afghanistan	AFG	1953	0.013685
...	...	...	...	...
26910	Zimbabwe	ZWE	2017	0.650533
26911	Zimbabwe	ZWE	2018	0.783639
26912	Zimbabwe	ZWE	2019	0.723861
26913	Zimbabwe	ZWE	2020	0.676970
26914	Zimbabwe	ZWE	2021	0.706293

26915 rows × 4 columns

Fig. 1. An example of the data set

After acquiring all the necessary data, the data process is to call the .csv file that contains the data. Using python to create the graph that matches the data, first join all the year and the anomaly since those are the main column for the graph, then second use seaborn (Python function) to graph.

```
# temperature anomaly of the world over the year
# where i get it: google search and https://www.ncsl.noaa.gov/access/monitoring/climate-at-a-glance/global/time-series
file_name = 'global_temperature_anomalies.csv'

# load the dataset
file_path = os.path.join(dataset_path, file_name)

# read in the data
temp_anomaly = pd.read_csv(file_path, header=0)
temp_anomaly = pd.DataFrame(temp_anomaly)
temp_anomaly.head()
```

	Year	Anomaly
0	1850	-0.11
1	1851	-0.02
2	1852	-0.06
3	1853	-0.14
4	1854	-0.01

Fig. 2. An example on how we load in our data

#### B. Data Process

The data is a summary of all the countries in the world about CO2 Emission. This is the unclean data that we created by importing all the CVS files data and create the graph using Python, this is the unclean data. As a visual class, this graph

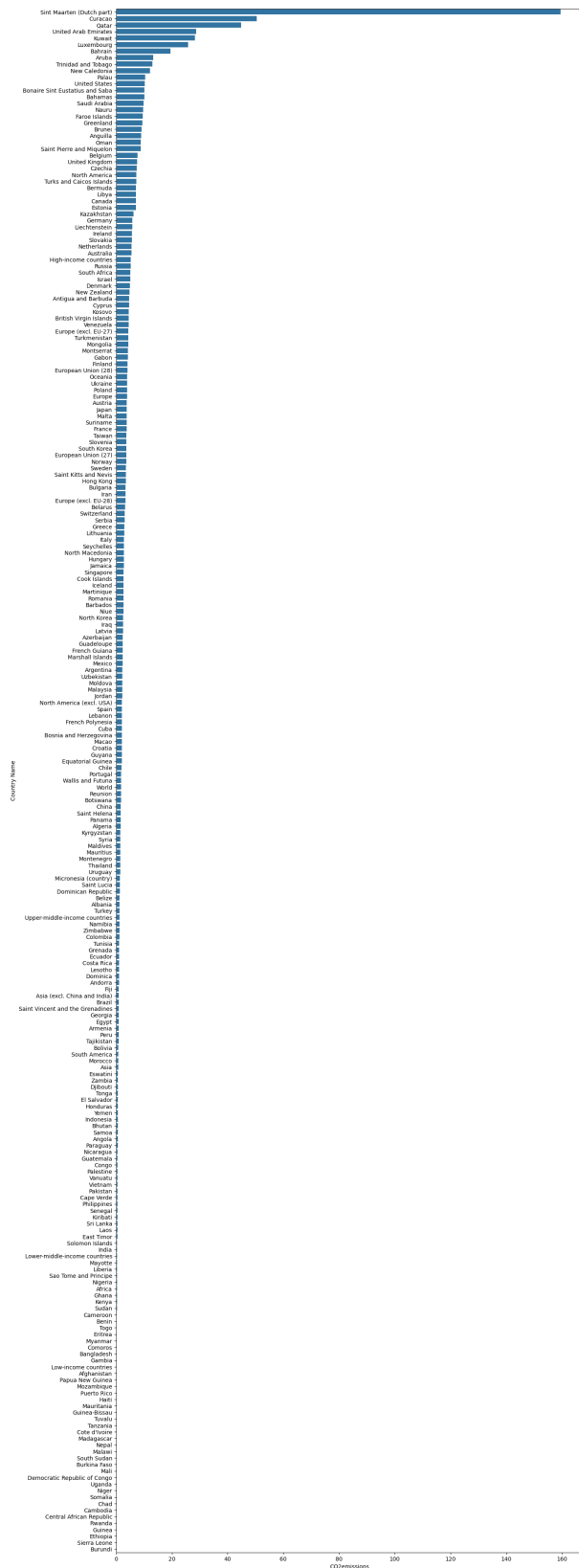


Fig. 3. An example on our 1st attempt to plot all data at once

does not deliver the main idea toward the user when they investigate the graph. Confused will be the first thought and visible (can't see) will be the second thought. Color will be the biggest impact because it all the same color to represent the CO2 release from each country, there are no main highlight color that indicate which it the country that release in median size. No title will be harder for viewer to analysis what the main idea this graph delivery.

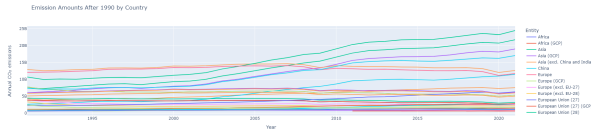


Fig. 4. Another attempt to plot the data before cleaning

This plot is the total of CO2 emission annual for top 10 countries. The line graph shows how the CO2 release overtime, but majority of the countries at the bottom have similar release, those can be cleaned up is into another graph (bar graph) and this graph only should capture the top 5 countries that fluctuate the most.

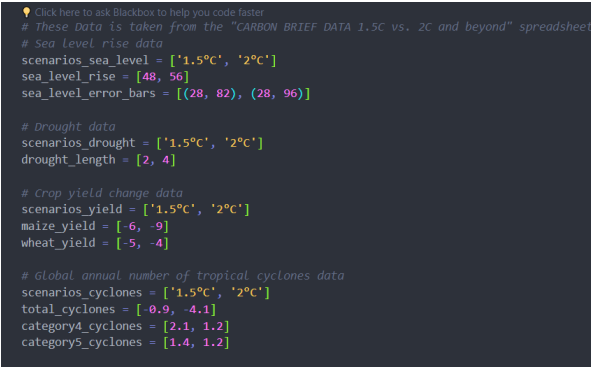


Fig. 5. Our attempt to manually input the data gather from a spreadsheet

The data for the sea level rise data is not come in as a .CSV file. Using Python to create array on how want the graph to be. In the picture here will be 4 data are sea level rise, drought, crop yield, and global annual number of tropical cyclones. This spreadsheet is taken from the Carbon Brief Data 1.5°C vs. 2°C and beyond.

Cleaning up the data using Python, creating an array for all the countries, then creating graph using seaborn function to generate graph. First importing library such as seaborn, matplotlib, then loading data using Pandas to inspect structure for understand when available data type and columns. Then data cleaning address outliers using Pandas for outliers detection. Utilize Seaborn is where the visual, then customize which graph (dot, bar). Seaborn is for data visualization help for process cleaning and using Python for representing graphically data. Creating the x-axis, y-axis, title by adding plt function to create the frame. Display the graph by adding plt. show () function.

```

# choose a few specific countries
countries = ['China', 'United States', 'India', 'Europe']
# create a new dataframe with only the chosen countries
share = share_co2[(share_co2['Entity'].isin(countries)) & (share_co2['Year'] == 2021)]
sum_countries = sum(share['Annual CO2 emissions'])
rest_world = share_co2[(share_co2['Entity'] == 'World') & (share_co2['Year'] == 2021)]
# print(rest_world)
sum_rest = float(rest_world['Annual CO2 emissions']) - sum_countries
# print(sum_rest)
share.loc[len(share.index)] = ['Rest of the World', 'RST', 2021, sum_rest]
# print(share)
# Explode the most significant section (United States)
# and plot the data to see how it has changed over time
cols = [
    'Annual CO2 emissions', 'Annual CO2 emissions including land-use change', 'Annual CO2 emissions from land-use change'
]
highlight = 'Annual CO2 emissions including land-use change'

us_data = global_co2_fossil_land[global_co2_fossil_land['Entity'] == 'United States']
us_data.set_index('Year', inplace=True)

xmax = us_data.index.max()
xmin = xmax - 100

title = 'Fossil Fuel and Land Use Change in US from {} to {}'.format(xmin, xmax)

# Call here to get the data to be plotted
disasters = ['Drought', 'Extreme temperature', 'Flood', 'Landslide', 'Wildfire', 'Extreme weather']

# Filter the dataframe to include only the selected disaster types and years from 1980 to 2022
filtered = num_disasters[num_disasters['Entity'].isin(disasters)] & (num_disasters['Year'] >= 1980) & (num_disasters['Year'] <= 2022)

# Create a pivot table for easy plotting
pivot_table = filtered.pivot(index='Year', columns='Entity', values='Number of reported natural disasters')

# Plot the data
pivot_table.heatmap(figsize=(16, 8))

# Specify colors for each category
colors = ['darkslateblue', 'olive', 'orange', 'steelblue', 'forestgreen', 'firebrick']

# Plot the data
pivot_table.plot(figsize=(20, 10), kind='bar', width=0.9, stacked=True, color=colors)
plt.xlabel('Year')
plt.ylabel('Number of Reported Disasters')
plt.title('Reported Disasters Over Years by Type')
plt.legend(title='Disaster Type')
plt.grid(axis='y') # Add a vertical grid line
plt.xticks(np.arange(0, len(pivot_table.index), 3), pivot_table.index[:3], rotation=0) # Adjust the step value for fewer ticks
plt.show()

```

Fig. 6. Examples of how we cleaning up our data

### III. WHAT IS THE PROBLEM?

**Climate Change** - Climate change, often referred to as global warming, or the greenhouse effect, is a change in the Earth's average temperature and cycles of weather patterns caused by human activities over a long period of time.

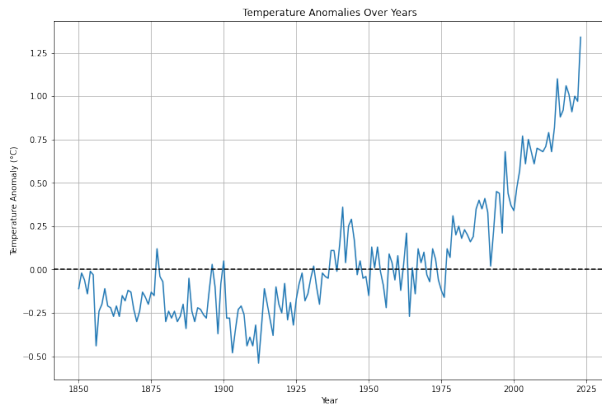


Fig. 7. Illustrate of Changes in Temperature over years

This is a plot of Temperature Anomalies recorded since 1850 in various parts of the world by means of thermometer-based records. There is a clear upward trend in terms of temperature data across the globe suggesting a warming trend. **This observed consistent rise in temperature is a clear indication of the changing climate.**

The emission of greenhouse gases (GHGs) such as CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O. These GHGs act as a blanket in the Earth's atmosphere, trapping heat and causing the temperature rise of Earth. The change in temperature may seem like a good sight for people living in the colder area of Earth because they will be experiencing a warmer winter than their usual cold weather.

However, only one gain but many unpleasant situations come along with the temperature warmer such as: destruction in the marine life for species that live in the colder area of water that their habitat got destroyed. Melting of glaciers, rising sea level, extreme weather events, ocean acidification, disruption of ecosystems, and threat to water resources. Our hypothesis is that global climate is a factor that caused by human over use the natural resources to development their country and lead to many affect that our earth has to face.

### IV. WHY IS IT A PROBLEM?

#### A. Increase in number of Natural Disasters

Over a long period of time species adapt gradually to fit well with their environment. This is supported by a stable climate that facilitates growth and adaptation of life. But rapid climate changes present a challenge: this implies that, organism has very short time for adaptation. Such rapid changes may sometimes prove hard for certain species to adapt with and consequently threaten their existence in a new surroundings.

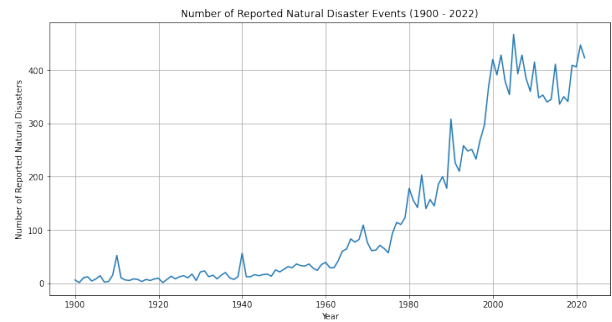


Fig. 8. Illustrate of Total Natural Disasters over years

Changes in climate cause different types of weather and more frequent extreme weather patterns. Such changes involve rising in the number of hurricanes, prolonged droughts, and more severe flooding. However, at the same time, one should take into account an association between increasing average temperatures around the world and rising numbers of witnessed natural disasters.

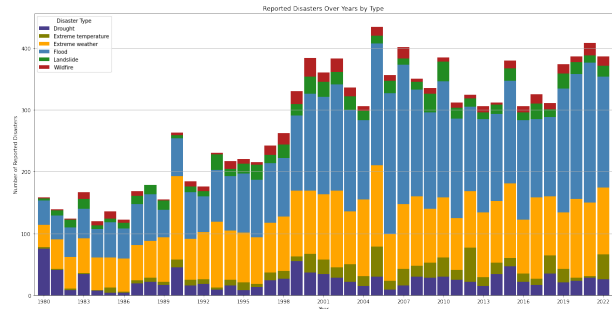


Fig. 9. Illustrate of Total Natural Disasters over years

The frequency of various types of disasters has increased for the last three decades, starting with year 1980. As the temperature keeps rising the amount of flooding, landslides,

and even wildfire has increased significantly. Furthermore, there has been more extremes of wind, heat and drought than used to be in times past.

80% of our Earth is covered by water so when global warming causes glaciers to melt causing a rise in sea level, then water evaporates causing drought, then follow that is increase in flood. Flood increase almost 50% compared to other disaster this mean our glaciers are melting at a fasting rate just in couple decade. As for the visual of the graph, it captures all the key details with a key box and clear distinct color indicates different disasters. Overall, the graph delivers to the viewer an easy-to-understand message it wants to deliver. Color makes a big impact on the delivery to viewer because people's eye understand color before understanding word. Stacking all the disasters over each other can give a sense of comparison for viewer to easily know which disaster happen more within the year or compare which disaster likely to occur over time.

### B. Sea level increase, Glacier receding

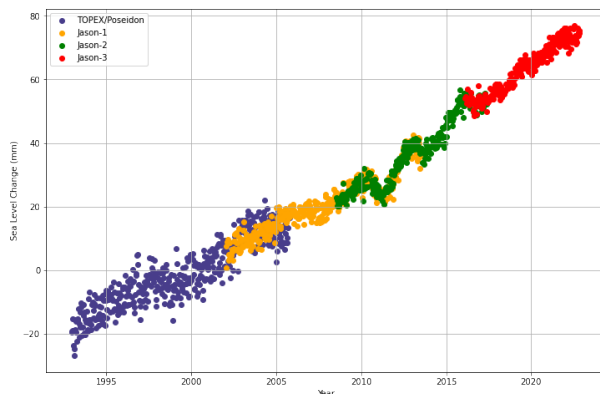


Fig. 10. Illustrate of Total Natural Disasters over years

Rising temperatures are also causing sea levels to increase. Over time, the rising water can cover coastal areas, destroying habitats and displacing whole populations from low-lying areas.

Rising sea levels are driven by two main processes:

- 1) **Ice Melt:** When the atmosphere and ocean get warmer, ice sheets and glaciers melt, resulting in the addition of fresh water to the ocean.
- 2) **Thermal Expansion:** As ocean water gets warmer, it expands, causing sea levels to rise.

The retreat of sea ice caused by increasing global temperatures has reduced the area of ice where many polar mammals engage in vital pursuits such as feeding, mating, and resting. This change poses a lot of problems to creatures like polar bears and seals by messing up with their feeding grounds as well as the breeding zones. The declining of ice makes it difficult the animals to find food and place of breeding as a well the rest.

Moreover, the bright surface of the ice reflects 80% of the sunlight that hits it back into space. This keeps the polar

regions cool and moderates the global climate. When the area of sea ice is reduced, less sunlight is reflected back into space. This causes more ocean warming and reduces the sea ice even further. This feedback drives faster climate change.

### C. Consequences of if we let the annual increase in global temperature spike even more

The temperature may continue going up even if we rush to take action due to the fact that the gases released into the atmosphere have made their effects known already. These issues that we already have will just become worse.

We need to act quickly to keep the temperature rise to minimum is extremely important for humans and wildlife.

### D. What is the different do you think a rise of 0.5°C in global temperature will make?

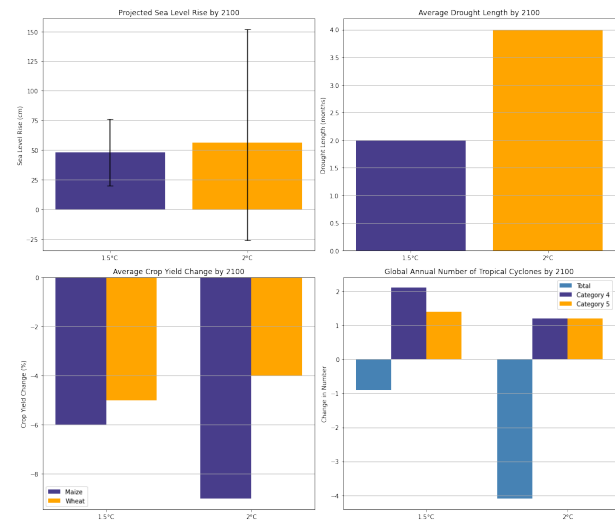


Fig. 11. Events predicted by 2100 with 0.5°C increase

Sea level will rise up to 8mm with just 0.5°C increase in temperature. With the water level rising, this may cause some of the countries that have a close surface to the sea level to disappear in the future. The plot graph inside the normal graph and this combination provides a friendly visual and can see the average of the sea level can rise. Drought lengths will increase significantly by 2 months because the warmer climate causes the water to emit causing water shortage in some countries. Increase in 0.5°C reduce maize production by 3%. With the temperature change some of the crops (food item) might go extinct. However, on the other hand wheat is having a best result. Lastly, reduce annually the total number of tropical cyclones by about 3, but more frequent high category cyclone (category 4-5)

Using different colors for the visual instead of using same color but different shades help viewer to identify faster. Also, easy to make a comparison and come up to the final solution.

## V. WHAT CAUSES CLIMATE CHANGE?

Climate change can be caused gradually by natural processes or suddenly by large events, such as a massive meteorite

strike or volcanic activity. However, the rapid climate change we are experiencing now is due to three main human activities:

- **The use of fossil fuels** like natural gas, oil and coal in heating and cooking; manufacture of electric and power generating units; motor engine operation creates carbon dioxide which is released into the atmosphere.
- Carbon dioxide is released by **deforestation** (decomposing of forests), reducing the number of trees that can absorb carbon dioxide from the air.
- **Deterioration in biodiversity** results to an erratic environment. Ecosystems become less efficient in absorbing carbon emissions as a result of nature loss, making them more susceptible to warming.

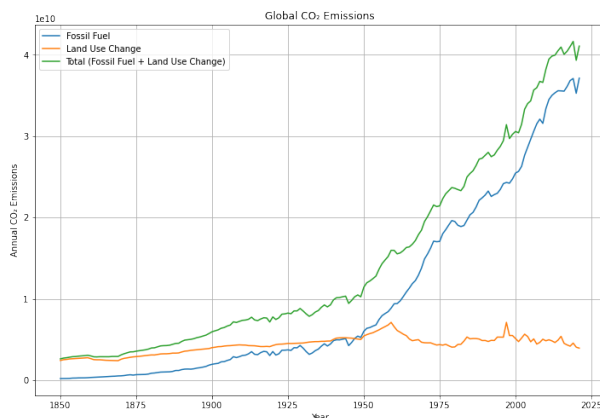


Fig. 12. Illustrate of the increasing of the World's CO2 Emissions by fossil fuels over years

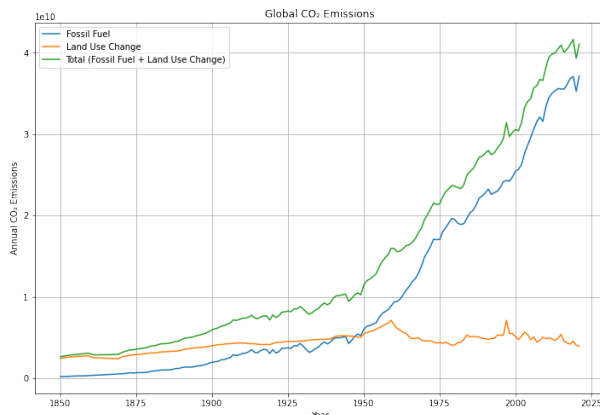


Fig. 13. Illustrate of the increasing of the US's CO2 Emissions by fossil fuels over years

## VI. WHO CAUSES CLIMATE CHANGE?

It is estimated that around 1% of greenhouse gases in the question of global warming are said to originate from the 50 most less-developed countries. On the other hand, inputs by the U.S, EU, and China accumulate about 60% of the World's CO2 Emission.

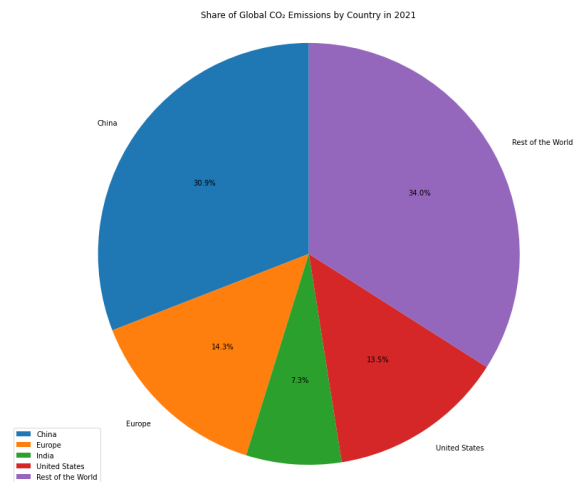


Fig. 14. Share of Global CO2 Emissions by Country in 2021

As the chart diagram shows that China is the country consumes the most CO2 Emission. China having over 1.4 billion people; moreover, for the last couple decade, China drastically develop from transportation, appliances use, and majority of their daily routine to technology and their goal is to fast and efficient. Untied State is the strongest country in development and technology, but only 13.5% of all the top nations. Fast development shows that all the countries with drastic development try to decrease everything that will damage the environment. Commonly used are bar graphs or line graphs but choosing the right graph to display the specific information that will catch the viewer also be the important task. Pie chart is the best way to display one problem but compare between other factors such as a share of global CO2 emissions in this example. The color distinct each country and with the impact of color make the user can just roughly know how much each country consume CO2 just by the color without looking at the percentage number.

## VII. WHO DOES CLIMATE CHANGE AFFECT?

In the long term, climate change effects have the potential to affect everyone. However, at the moment, certain people and areas have an unequal share of its impact.

Rich nations have always made money from activities which cause global warming. Due to this financial benefit, these nations can shield themselves immediately from climatic changes' impacts.

The poorest countries confront more difficult times to adapt, and they suffer the worst impacts associated with such changes in climate. Despite facing climate related adversities, their development is impeded by their limited resources and capacity due to this factor.

**However, it is ironic that the countries most unaffected by the climate crisis suffer from it the most, implying an asymmetry between culpability and hardship.**

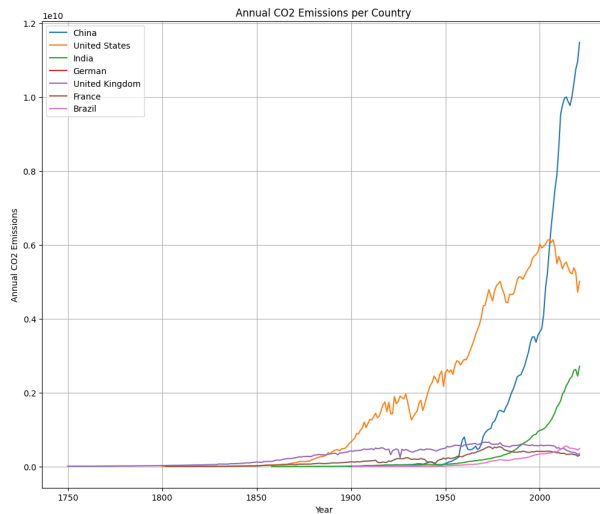


Fig. 15. Annual CO2 Emissions per Country

## VIII. CONCLUSION

Global warming is a big problem that our community, our earth, and our society have been facing. From what we research and noticed that there are many factors that affect that happen in everyday routine. The data presents many developed countries that release the most amount of CO2 everyday into the atmosphere, but they have a strong economy to recycle and decrease the amount of CO2 for their country. However other smaller countries with less economy must facing the CO2 that release from other strong economy countries. Some changes need to be made in the future such as converting to electric vehicles, reducing the economy of waste and recycling, investing in technology that capture and store carbon, and shifting from fossil fuels to renewable energy source is solar. After research and gathering data, we support our hypothesis that during many years of revolution into the development countries every country keeps invented and make their countries stronger by overuse of the natural resource without a good recycle plan. Causing many unexpected disasters and destroy our ecosystem within our Earth.

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