SUBJECT: ISM 6361
DATA VISUALIZATION

TOPIC: GREENHOUSE GAS EMISSIONS

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INTRODUCTION:

Gases that trap heat in the atmosphere are called greenhouse gases. This Project provides information on emissions of the main greenhouse gases to and from the atmosphere. For this study, I have chosen the top 3 significant gases for the green house effect.

- **Carbon dioxide (CO_2)**: Carbon dioxide enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and other biological materials, and also as a result of certain chemical reactions (e.g., cement production
- **Methane (CH_4)**: Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices, land use, and by the decay of organic waste in municipal solid waste landfills.
- **Nitrous oxide (N_2O)**: Nitrous oxide is emitted during agricultural, land use, and industrial activities; combustion of fossil fuels and solid waste; as well as during treatment of wastewater.

These gas concentrations are measured in million metric tons. Each of these gases can remain in the atmosphere for different amounts of time, ranging from a few years to thousands of years. All of these gases remain in the atmosphere long enough to become well mixed.

BUSINESS JUSTIFICATION:

Over the years, people have consumed more fuels such as wood, coal, oil, natural gas, and gasoline. The gases formed by the burning, such as carbon dioxide, are building up in the atmosphere. As a result, researchers believe the Earth is heating up and experiencing change the climate.

In this project, I have created a visualization to examine the Green house gas emissions, which includes CO2, Methane and Nitrous Oxide atmospheric concentrations, as well as trends in global warming, such as rising sea levels, heat generation and frequency of natural disasters which are key indicators to monitor climate change and its impacts on populations.

DATA SOURCE

The data I have collected is from United States Environment Protection Agency (EPA). The Environmental Protection Agency protects people and the environment from significant health risks, sponsors and conducts research, and develops and enforces environmental regulations. This file contains publicly available reported emissions data at the unit-level for facilities.

Facilities report emissions from many process types defined by the GHGRP. The Greenhouse Gas Reporting Program (GHGRP) collects Greenhouse Gas data from large emitting facilities, suppliers of fossil fuels and industrial gases that result in GHG emissions when used, and facilities that inject carbon dioxide underground. Approximately 8,000 facilities are required to report their emissions annually, and the reported data are made available to the public in October of each year.

Based on further research, I found the data for the impact of Greehouse gases over time form IMF Climate Change Dashboard. Although this dataset has the emissions monitored from 1980, For this study I have filtered the data only from 2010 to 2022.

TABLEAU – FEATURES USED

I believe that learning this tool has helped me learn a lot on how to make a perfect graph based on the different scales and Information that is present in the dataset. One major insight on using this tool was that the analysis was faster. The graphics in Tableau and the User Interface were very simple and easy to understand. I was able to implement the lessons learnt in class as well as the textbooks while preparing charts in this tool. Below are some of the Features I used in creating the visualization.

1. **Connect Data:** Tableau supports connecting to a wide variety of data, stored in a variety of places. For this study, I connected the Data from Excel.

2. **Filter:** After Connecting the Data I used the filter option to remove the data from 1980 to 2010. Because the study is based only from 2010 onwards.

3. **Pivot:** In the Climate-related disasters data collected, the years were represented in columns. Which was over 44 years. I used the pivot option in Tableau to change them into rows so that it could be easier to track the number of disasters over time.

4. **Maps:** Maps have 2 types of which I used Fill. Firstly, I used Tableau inbuilt outdoors map to represent the Methane emission based on Industry type.
   Second, I used a third-party map from Mapbox to represent city-wise CO2 emissions.

5. **Motion:** I have used Motion in 2 different Charts, first is in Change in Sea Level and the other one is Climate related disasters. There are 2 important things to keep in mind, one is to remove the mark from automatic and I used Shapes instead. Another one is to apply "Years" in Pages shelf. So that the changes in Sea level/Climate related disasters can be measured over the years from 2010 to 2022.

6. **Calculations:**
    - For this project, most of the charts uses Aggregation, Although Tableau has Sum as a default setting, I have also used Average and Mean for the charts to represent the data.
    - I have calculated subtotals which summarize CO2 emission for different Industry type for each state.

7. **Quick Table Calculations:** This is used on data that is summarized in table and we use calculation that summarized data. In this project I have used Quick table calculation to calculate the percentage of total for Unit Bio-genic CO2 emission and Unit Non-Biogenic CO2 emission (Metric Tons)

8. **Forecasting:** This is a technique that uses historical data to make informed estimates that are predictive in determining the direction of future trends in the increase in Sea Level. From the analytics tab, I used forecasting for the Change in Sea levels for the next 3 years and to forecast the Methane and N2O emission in metric tons for the next five years

9. **Parameter:** This is used for the user to have a choice to switch between different sheets in a single visualization. It is a multi step process where we create a parameter, then display the parameter and then create a calculated field for that parameter. In this Project I have used parameter for CO2, Methane and N2O emissions in metric tons

10. **Create Calculated Field:** An "IF" statement calculation that I used to get the parameters.
    IF [Emmissions] = "CO2" THEN [Unit CO2 emissions (non-biogenic)]
    ELSEIF [Emmissions] = "Methane" THEN [Unit Methane (CH4) emissions]
    ELSE [Unit Nitrous Oxide (N2O) emissions]
    END

11. **Dashboard:** It is where we putting everything together, It is an interactive place where we can add an action like filter when you select/click/hover to perform integration between the visualizations created. Here I have created a dashboard for Maps of CO2, Methane and N2O emissions, Parameter and Combined CO2 emissions. We can also add text, Images, web pages etc.

12. **Story:** This is where we use the visualizations created or dashboards and add them to a story. It is a collection of visuals that are put together to deliver information. Users may engage with the story to discover new insights or pose new questions to the data. This works like a presentation where they can also be a compelling data storytelling tool.

REASON FOR VISUALIZATION

LINE GRAPH: Discrete and Continuous

These graphs show how numbers have changed over time. They are used when you have data that are connected, and to show trends. I have used this chart to visualize the following:

a) Parameter – CO2, Methane and N2O emissions (in metric tons) over time - Continuous
b) Climate-Related Disasters – Discrete
c) Methane and N2O emissions – Dual line chart is used because it has 2 measures with different scale but with a same trend. Hence I have used this to forecast the emissions for the next 5 years.
d) Rise in Sea Level- This is used to measure the rise in sea level over time. I have used line graph to forecast the rise in sea level for the next 5 years

MAPS

Maps are used for geographic analysis. I have used maps to visualize the following:

a) Amount CO2 emissions in different cities of USA- For this I used Mapbox to get a third-party 3D map so that additional layers could be seen. With the color denser we can answer questions like which city has more CO2 emissions.
b) Methane emission based on industry type: This data is represented in maps to answer questions like which state has the most emission and also which industry type is emitting more methane gas in the given state.

AREA CHART

This chart is commonly used to represent Area showcase data that depicts a time-series relationship. I have used this chart to represent the motion of change in sea level over time with mean sea level changes for each of the world's main seas and oceans.

PACKED-BUBBLES CHART

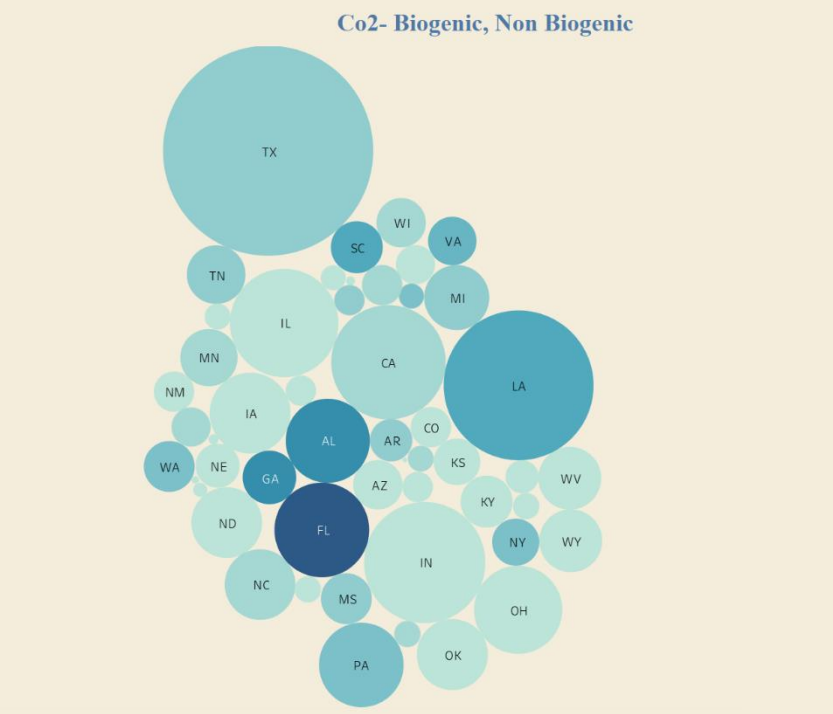
Packed bubble charts are visualizations where the size and optionally the color of the bubbles are used to visualize the data. I have used this chart to measure the combined CO2 emission in different states of USA. The size of the bubble depicts Non biogenic CO2 emissions and the color of the bubble represents Biogenic CO2 emissions in different states of USA

TREE MAPS

I have used these charts to determine the maximum heat generated based on unit type. These charts capture relative sizes of data categories, allowing for quick perception of the items that are large contributors to each category.

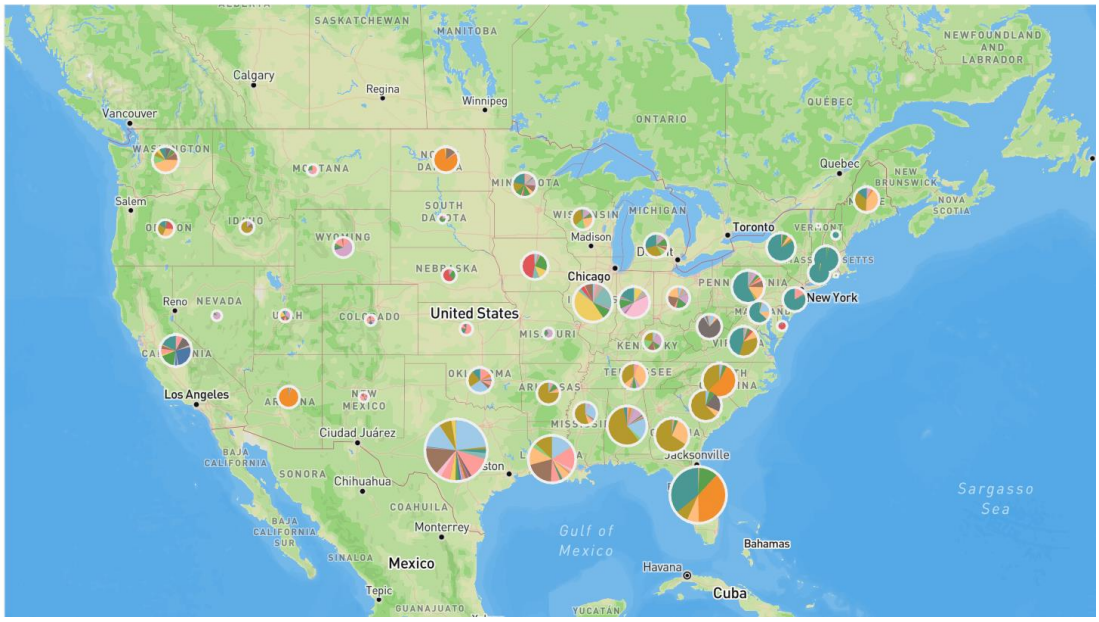
ANALYSIS OF THE OUTPUT

Through this visualization project I was able to analyze the collection of comprehensive, nationwide emissions data. It has been very useful to have these infographics to understand the major effects on climate change and rising sea levels across the globe. It provides a better understanding of the sources of Greenhouse Gases and guides development of policies and programs to reduce emissions.



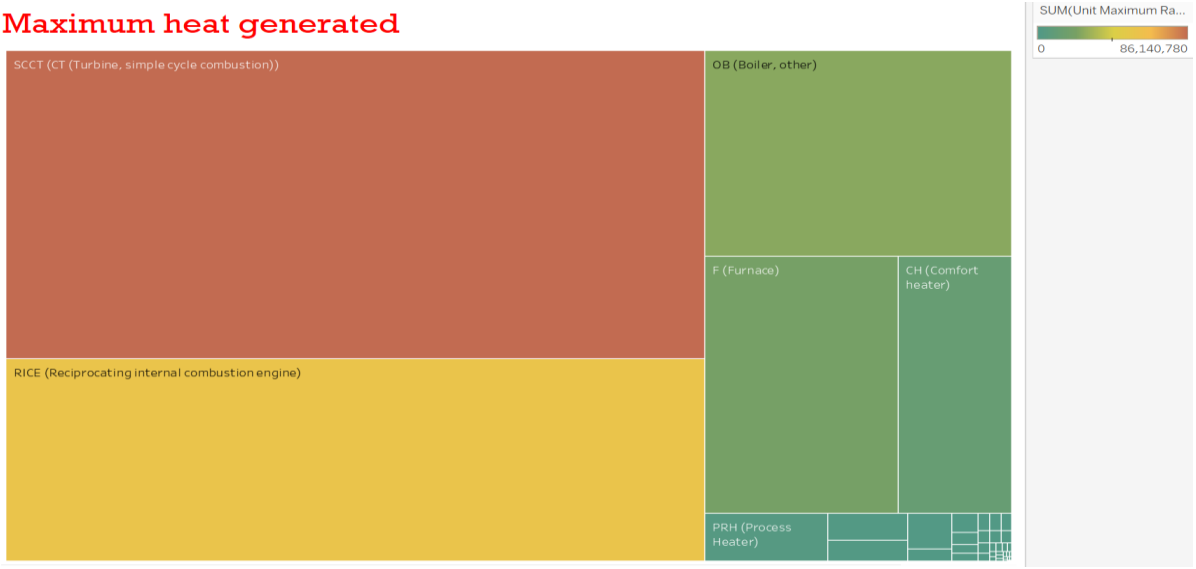
Interpretation: Changes in CO2 emissions from fossil fuel combustion are influenced by many long-term and short-term factors, including population growth, economic growth, changing energy prices, new technologies, changing behavior, and seasonal temperatures. We can see that Texas has the highest Non-Biogenic CO2 emissions and Florida has the highest Biogenic CO2 emissions.

METHANE EMISSION BASED ON INDUSTRY TYPE

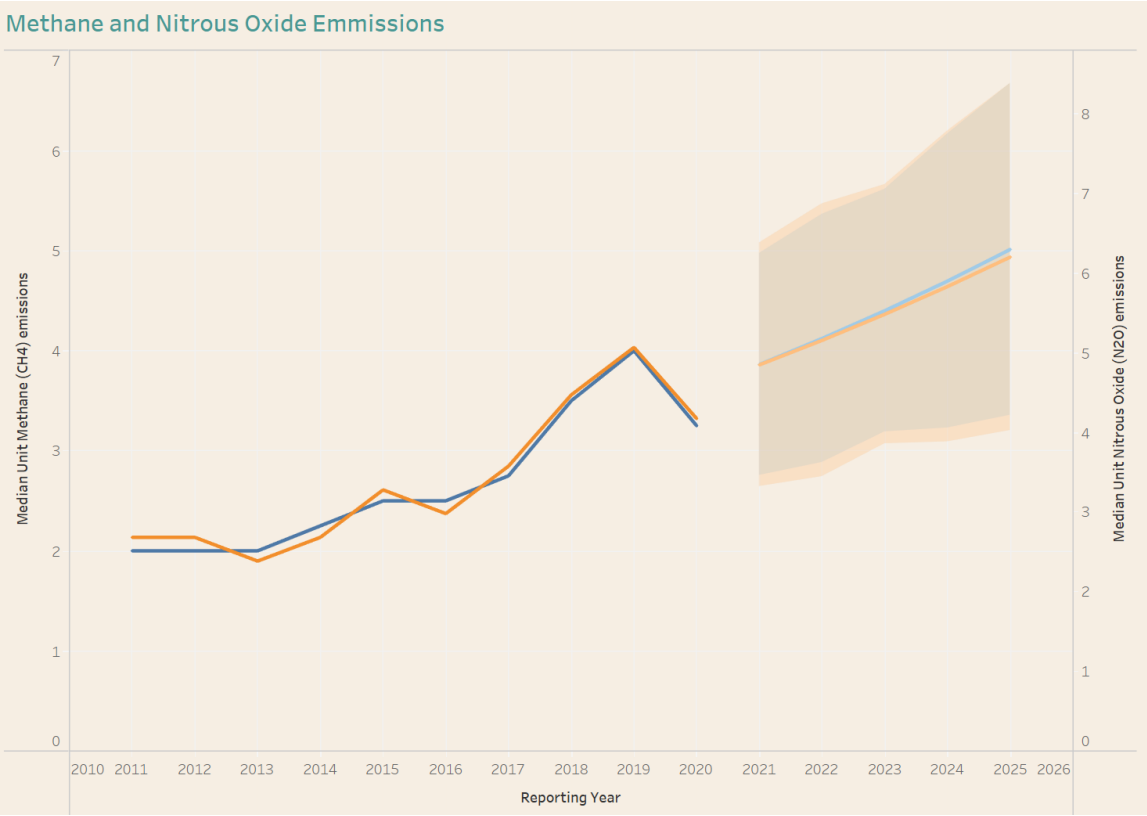


From the above map, we can see that Texas has the highest methane Emission. The highest contributor is the chemicals industry, and the second highest is power plants. We can also see the different types of industries have different amounts of methane emissions in the atmosphere. The size of the circle represents Amount of methane emissions, and the colors represent methane gas. From this analysis we can suggest that the power plants are the largest source of CH4 emissions in the United States.

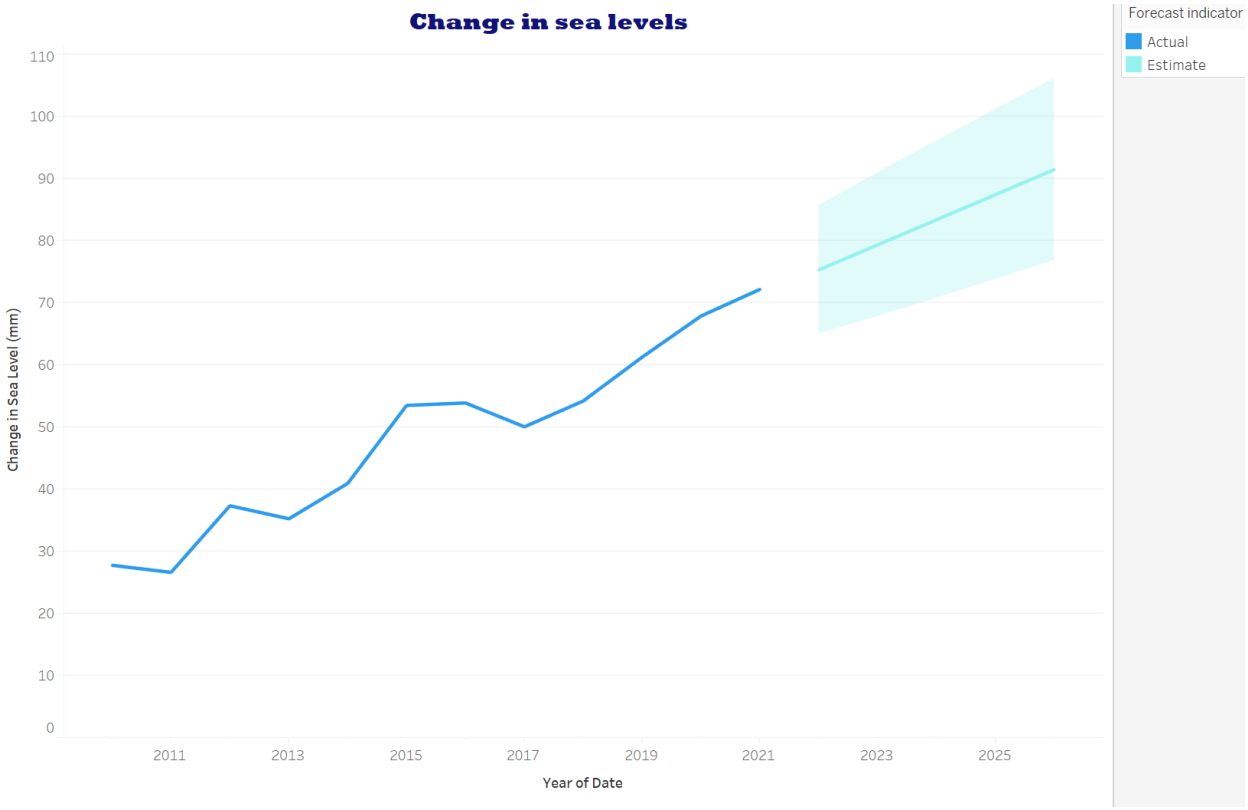
Maximum heat generated



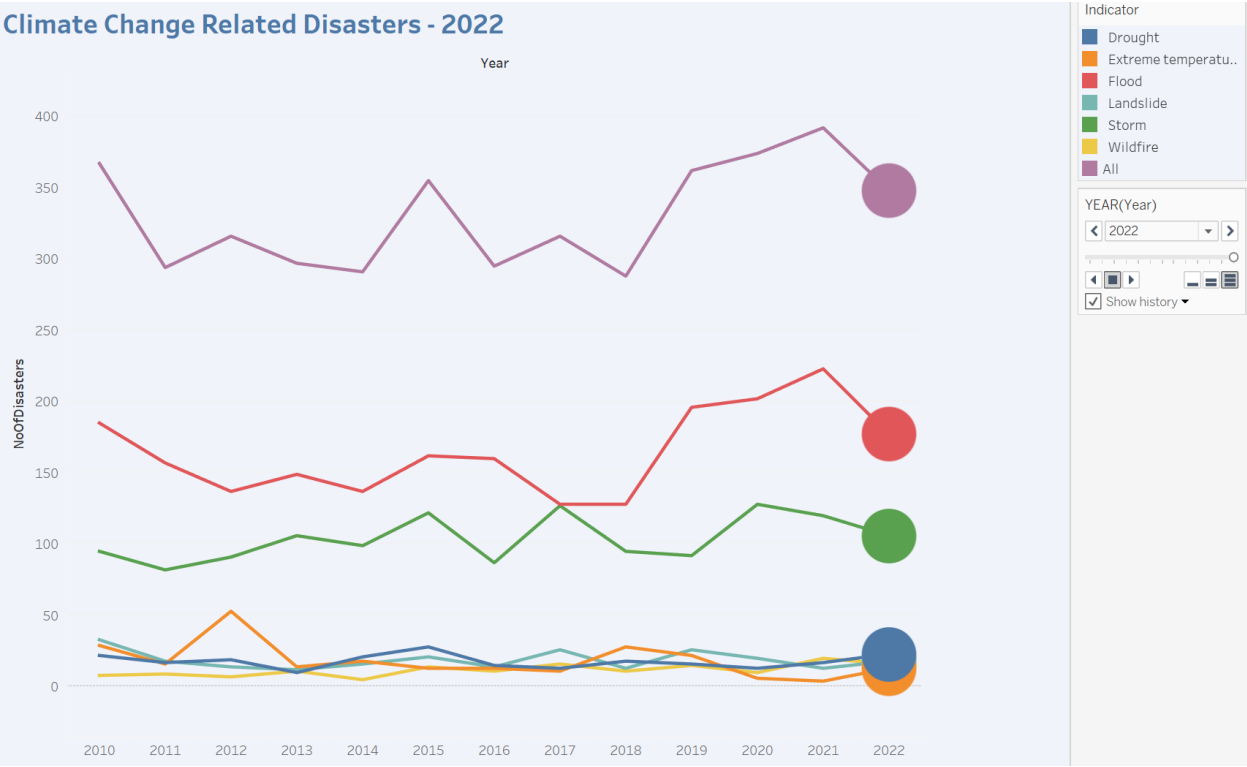
From this data we can observe that the maximum heat generated is from Turbines and 3/4th of it is from reciprocating combustion engine. This is a very important aspect to the effect of heat trapped which gives a long-term effect on global warming and climate change.



From the above line graph, we can see that Methane and N2O emissions in the United States decreased by 12% between 2018 and 2020. During this time period, emissions decreased from sources including landfills and coal mining and from natural gas and petroleum systems. But considering the historical data, I used forecast for the next 5 years, here we can see that there could be a significant increase in methane and N2O. There are several ways to reduce CH4 emissions like upgrading the equipment used to produce, store, and transport oil and natural gas can reduce many of the leaks that contribute to CH4 emissions. Methane from coal mines can also be captured and used for energy.



There has been a significant increase in the sea level upto 38% from 2011 to 2021 globally. This is a major impact of climate change caused by global warming. This indicator gives estimates of the rise of global sea levels, based on measurements from satellite radar altimeters. These are produced by measuring the time it takes a radar pulse to make a round-trip from the satellite to the sea surface and back again. Seeing this increasing trend in the rise of sea level, I used forecasting to determine the mean increase of sea level for the next 5 years and found that the potential of increase as compared to 2011 would be 70% higher.



This graph depicts the trend in these climate-related disasters over time. From this analysis we can see that the links between climate change and natural disasters are well documented in a wide variety of climate change study. We can see that there is an increasing trend of flood from 2018-2020. This can be linked with the rising sea levels caused by atmospheric changes across the globe.

CONCLUSION

U.S. greenhouse gas emissions decreased from 2019 to 2020 by 9 percent. This sharp decline is largely due to the impacts of the coronavirus (COVID-19) pandemic on travel and economic activity.

A number of factors influence the quantities of greenhouse gases released into the atmosphere, including economic activity, population, consumption patterns, energy prices, land use, and technology. Among the various sectors of the U.S. economy, electricity generation (power plants) accounts for the largest share of historical emissions—31 percent of total greenhouse gas emissions since 2011.

This analysis measures the heating effect caused by greenhouse gases in the atmosphere. Rising global average temperature is associated with widespread changes in weather patterns. Thus we can conclude that The atmospheric quantities of carbon dioxide, methane, and nitrous oxide influence global warming patterns such as rising sea levels, rising temperatures, and the frequency of natural disasters.

DATA SOURCE:

1) United States Environment Protection Agency :

EPA publishes the publicly available data from the GHGRP. The publication tool called FLIGHT (Facility Level Information on GreenHouse gas Tool) was developed anticipating use by the public

https://www.epa.gov/system/files/other-files/2022-10/emissions_by_unit_and_fuel_type_c_d_aa_10_2022.zip

https://www.epa.gov/ghgreporting/data-sets

2) Climate change related Dataset:

https://climatedata.imf.org/pages/climatechange-data

3) Other References for Global warming related information:

https://ourworldindata.org/co2-and-greenhouse-gas-emissions#why-do-greenhouse-gas-emissions-matter

https://en.wikipedia.org/wiki/Greenhouse_gas_emissions

https://www.nationalacademies.org/based-on-science/climate-change-humans-are-causing-global-warming?gclid=CjwKCAjw9J2iBhBPEiwAErwpeV17sd62ucuvW4K-sTzrwu5nBwAI3q6OcORR8_LoZs-jeaPVAKcnghoCaTYQAvD_BwE

3 Ws

1. What went well?

It was fun creating the visualization. I was able to understand and implement the Do's and don'ts of creating a Chart. Tableau is a really interesting and user-friendly tool. I had enough time to explore different features and understand them in detail.

2. What Did not go well?

Initially, It was difficult to visualize data only on Methane emissions, Which is when I realized to broaden my topic from just one Greenhouse Gas to top 3 Greenhouse Gases which is CO2, N2O and CH4. Only after I did this, I was able to analyze the importance of keeping our environment safe.

Another thing that did not go well is that I could not find a free version of map which had "Sea/Oceans" in its layers. I Would have been really cool to visualize the rising sea levels on a map.

3. What I would do differently next time?

Find more data to find links between the different gases and create multiple visualizations with interactive dashboards.

TABLEAU PUBLIC- LINK

GREENHOUSE GAS emissions | Tableau Public