# DATA VISUALIZATION ON GLOBAL WARMING: IT'S CAUSES AND EFFECTS


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## INTRODUCTION

Since the advent of industrial revolution, the concentration of atmospheric gases such as carbon dioxide, methane, chlorofluorocarbons etc., have risen exponentially. While some of the contributions are from the nature itself, majority of them are man-made. This has resulted in abrupt increase in earth's surface temperature over the past few decades due to the accelerated greenhouse effect.

Greenhouse effect is a natural process by which the earth's surface is kept warm by radiating the sun's energy back to it by atmospheric gases such as carbon dioxide ($CO_2$), water vapor, methane($CH_4$) and nitrous oxide($N_2O$). The process starts when the sun's light hits the earth, some of the energy is absorbed by the earth and remaining is radiated back to the atmosphere thereby initiating the greenhouse process. This process is very much essential to keep the planet warm and sustain life.

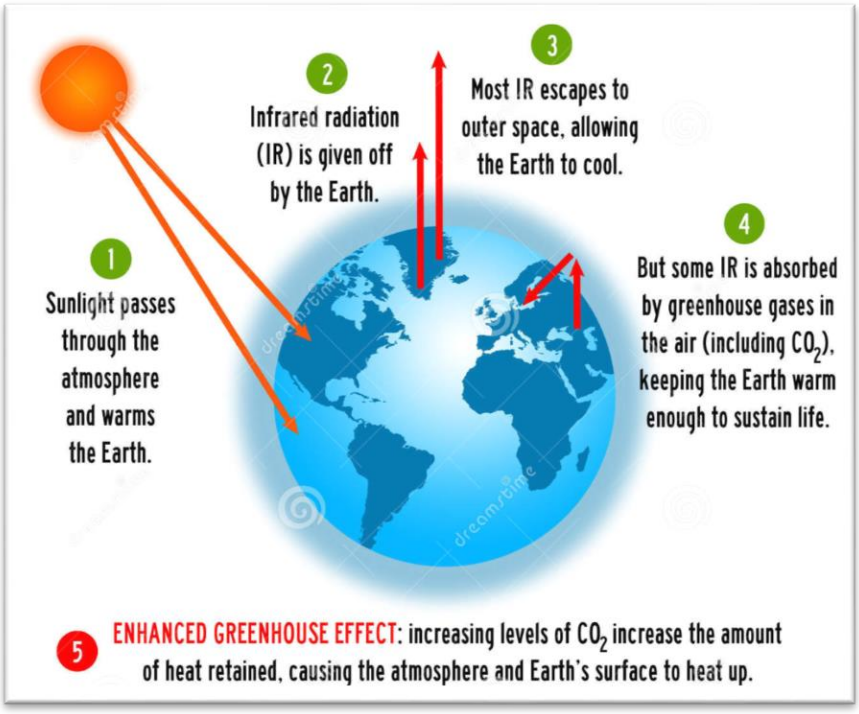



Figure 1. Greenhouse effect Illustration

Post industrial revolution, the concentration of greenhouse gases is in the rise due to the burning of fossil fuels, cutting down of forest areas to make room for agriculture, increased meat production, increased population resulting in increased earth's surface temperature and melting of polar ice caps. This phenomenon is referred to as '**Global Warming**'. Its impacts include rise in sea level, powerful hurricanes, abnormal weather patterns, severe drought etc.,

## Motivation

The motive behind selection of this topic is to convey the causes and effects of global warming using visualization techniques and showcase how the man-made emissions are effecting our planet. Although this topic has been discussed since a long time, general public must be made aware of its devastating consequences if no action is taken against it.

The cause of global warming can be categorized into two factors:

1. Natural cause
2. Man-made cause

## Natural Causes

**Forest fire**: They occur by either lightning strike or by spontaneous combustion of sawdust and dry leaves. Forest fires emit large amount of carbon-filled gas into atmosphere. Usually they burn for a long duration before being detected.

**Permafrost**: Refers to frozen soil which contains carbon dioxide and methane, these are usually found at Arctic and Antarctic regions, they trap these gases from entering atmosphere. However, due to increased temperature the ice caps are melting at faster rates releasing these gases.

**Sunspots:** A rare occurrence where in a sudden release of energy from the sun in the form of solar flares. They are charged particles carrying vast amounts of energy. They collide with earth's ionosphere causing magnetic storms disrupting radio and cell phone communication.

**Water Vapor:** As the temperature rises, the atmospheric air temperature also rises, heated air can hold more moisture. As a result, more water is evaporated from rivers and lakes causing the moisture content in the atmosphere to increase. As water vapor is a greenhouse gas, it will trap more heat causing further increase in temperature.

**Volcanoes**: Volcanic eruptions throw large amount of gases like sulfur dioxide, water vapor, carbon dioxide and dust into atmosphere. Although volcanoes are responsible for emitting about 200 million tons of carbon dioxide annually, it is nowhere close to the amount generated by man-made emissions.

**Oceans:** They naturally balance the carbon dioxide content in the atmosphere by absorbing it, in addition they also absorb it from sea floor in the form of calcium carbonate. As more carbon enters to atmosphere, the ocean must absorb more of it thereby decreasing its pH content. This leads to acidification of ocean water which will be hazardous to some aquatic animals.

## Man-made Causes

**Deforestation:** Forests are the primary source of oxygen for living beings, they release oxygen as a part of photosynthesis by absorbing atmospheric carbon dioxide. However, they have been cut down in an unprecedented scale to make way for crop cultivation, cattle rearing, construction of roads etc., This not only affects the ecosystem and the wildlife but also the increases the carbon concentration in atmosphere as there won't be much trees to absorb them.

**Fossil Fuels:** The prime contributor to global warming, fuels like coal, petrol, diesel, kerosene release substantial amounts of carbon dioxide on combustion. Much of the world's electricity is generated by burning of fossil fuels. Vehicles, factories emit harmful gases such as nitrous oxide, methane, carbon monoxide which mix with air and water thereby causing air and water pollution. Burning of fossil fuels releases around 21.3 billion tonnes of carbon dioxide into atmosphere.

**Landfills:** They refer to the wastes generated by factories and normal household garbage, often they are recycled by burning them. They release harmful gases such as methane, ammonia, carbon dioxide, sulfur into atmosphere.

**Fertilizers**: The use of pesticides and fertilizers for agriculture has led to the increase in nitrous oxide content in atmosphere. This is because nitrogen based fertilizers stimulate the microbes in the soil to convert nitrogen into nitrous oxide at a faster rate. Nitrous oxide being a key greenhouse gas then traps more heat and traps it from escaping the atmosphere.

**Meat Consumption:** Due to the increase in popularity of fast food restaurants serving meat, there has been increase in rearing of farm animals. They emit gases like carbon dioxide, methane through their natural biological processes. However, as these animals are reared in large numbers over a small area, greenhouse emissions per acre of land vastly increases when compared to the emissions made by wildlife as they are spread apart over large area.

**Urbanization**: As cities start to expand due to increasing population, there will be lesser vegetation to absorb carbon dioxide. More population leads to increased vehicles, which means more pollution.

Man-made pollutions are accelerating the rate of global warming much faster than the natural causes, this has resulted in several variations in climate all over the globe. This can be inferred by examining the several factors that support this claim.

The below sections illustrate the evidences that support global warming, its causes and impacts through business queries and visualizations that support them.

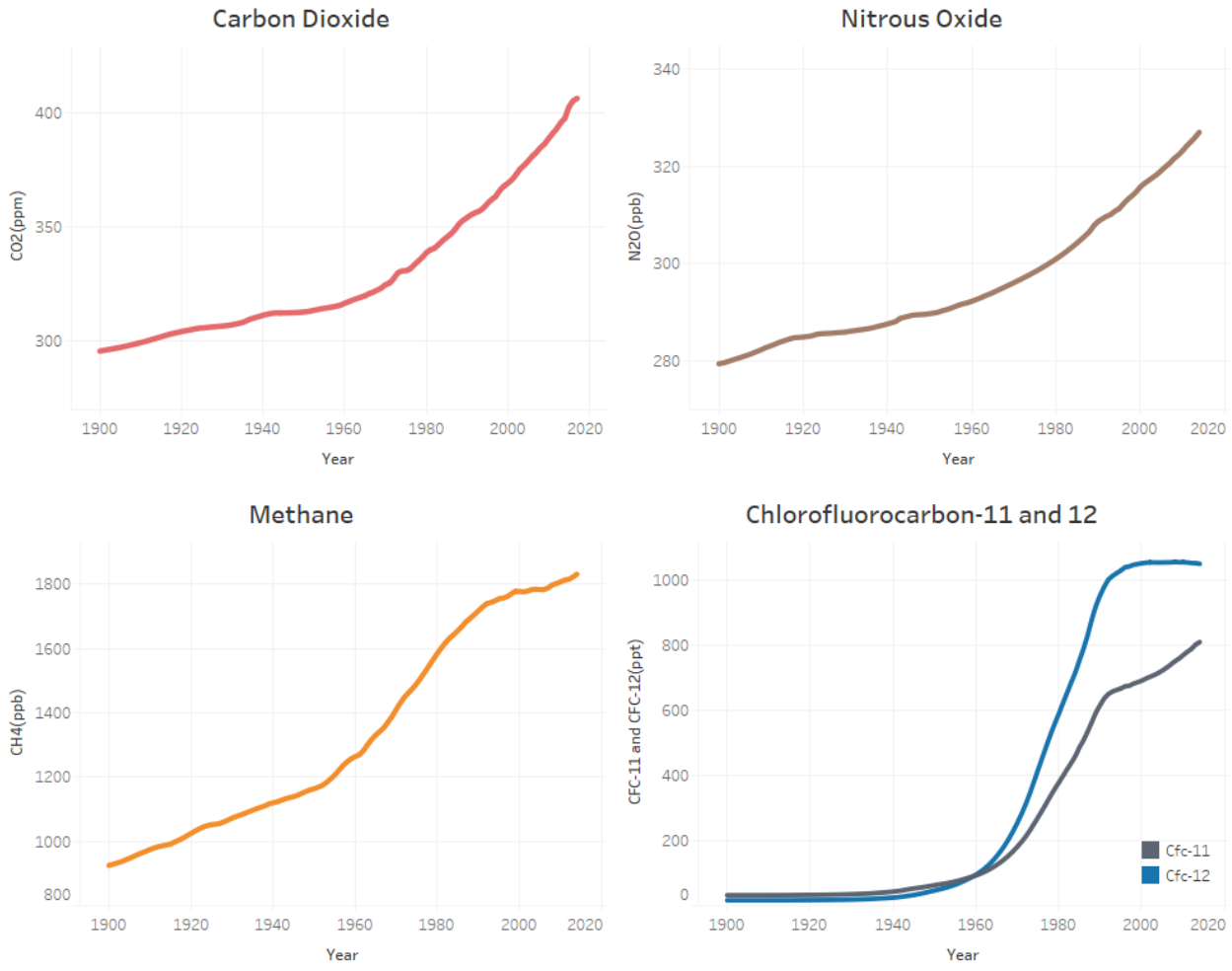
The data is extracted from various websites. No data cleaning was required as there were no missing items in the datasets. Visualization is done using Tableau (Version 10.3) software.

## Business Queries

**Query 1**: ***What are the evidences that support global warming claim?***

The concentration of greenhouse gases in the atmosphere directly influence the temperature of land and the ocean. As the concentration of greenhouse gases increases, there will be more trapping of heat and hence increase in temperature. Below sections describe how the concentration of greenhouse gases have changed over time and how it has affected the land and sea bodies.

<u>Increase in Greenhouse gases concentration in the atmosphere</u>

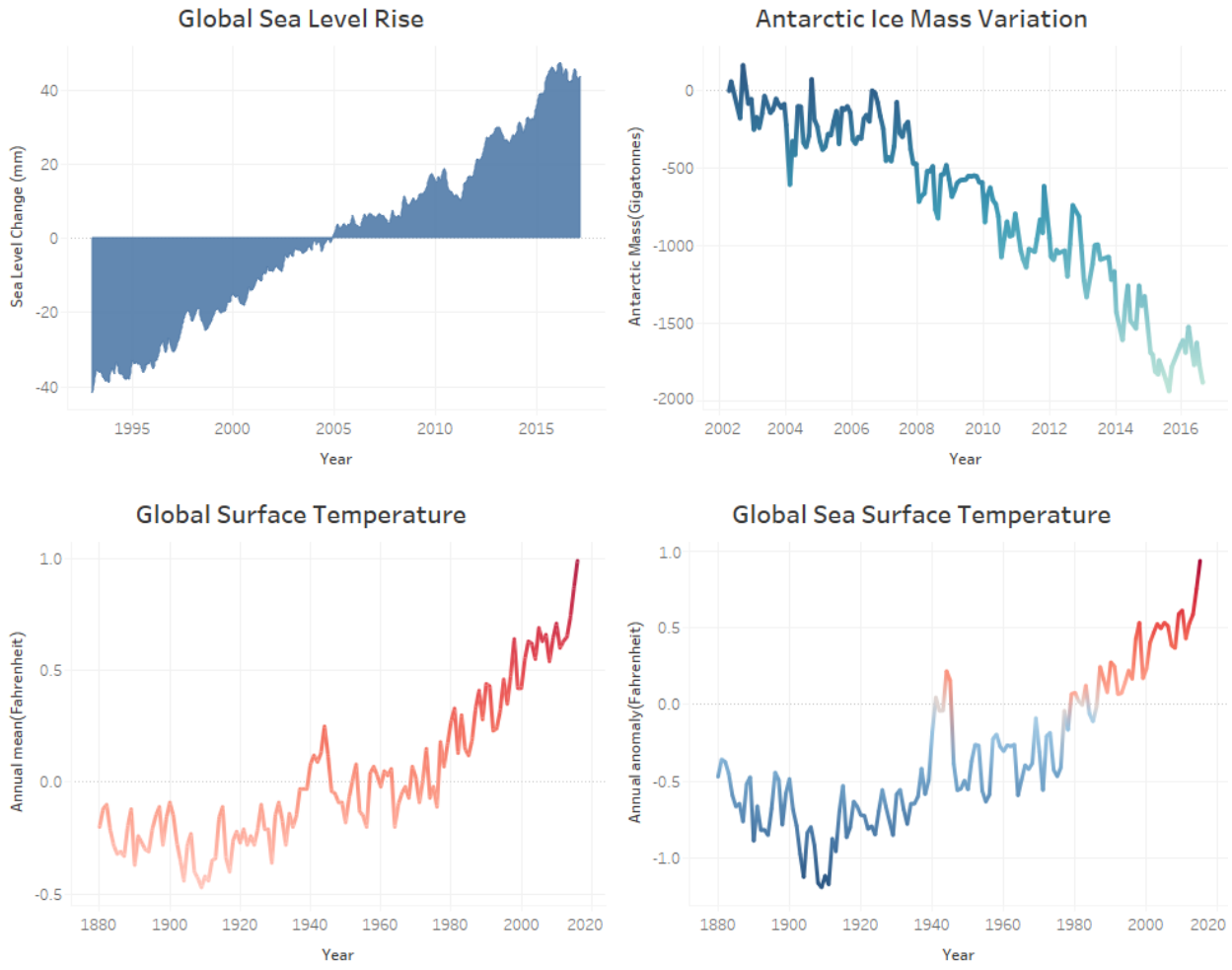



Above graph shows the annual average Greenhouse gas levels in the atmosphere. There has been a significant rise the concentration levels from 1960 onwards. This is due to increase in vehicles,

industries, population and fossil fuel consumption. Carbon dioxide, methane, CFC-11 and 12 are the byproducts of fossil fuel combustion.

There is an upward trend for nitrous oxide because it is one of the component of fertilizers which are used for agriculture. It increases the ability of the soil to convert atmospheric nitrogen into nitrous oxide resulting in increased concentration in atmosphere.

Impact on Land and Oceans

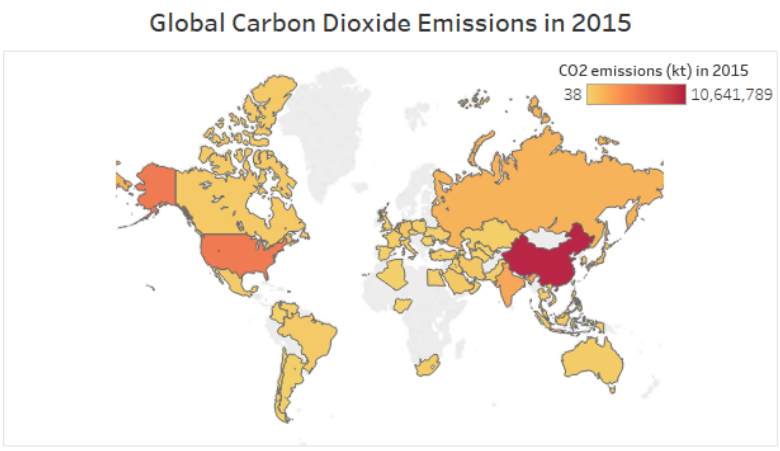


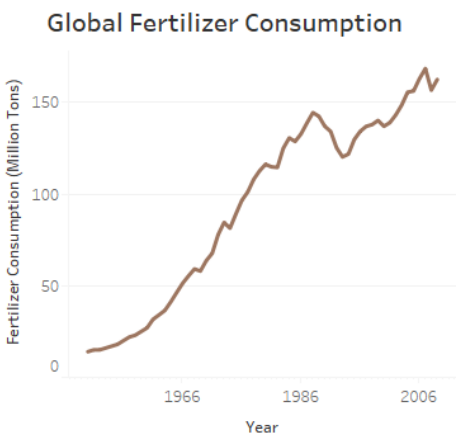

The above graph shows the rise in sea level since 2005, it is mainly caused by two factors: Melting of glaciers adds more water to the oceans and expansion of warm sea water due to rise in temperature. The above two reasons can be inferred by looking at the plots of Antarctic ice mass deterioration and rise in sea and land temperature.

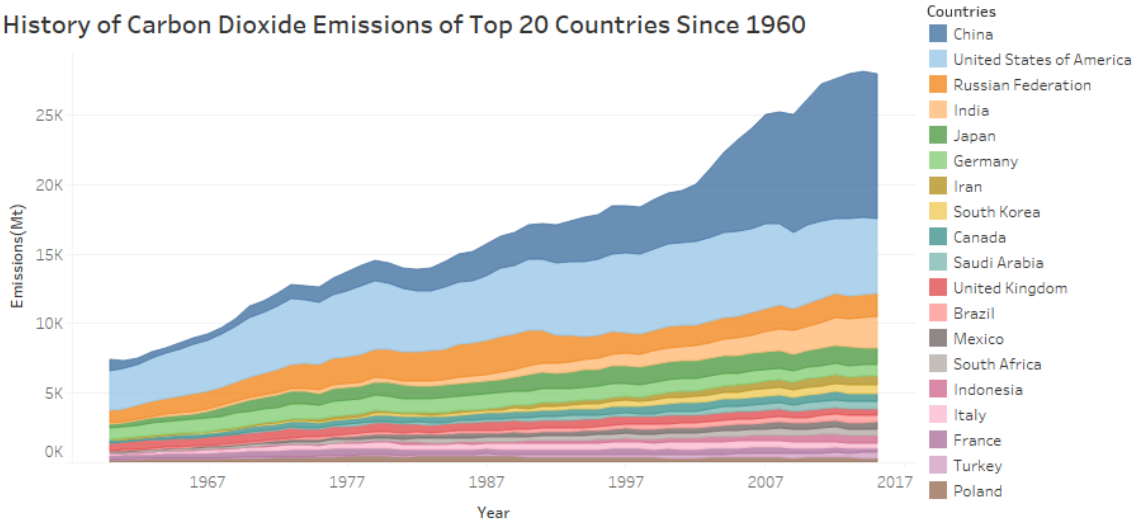
Rise is surface temperature leads to the melting of ice and increase in sea level, once the surface is heated, water in the oceans also get heated up and start to expand which leads to further rise in sea level.

**Query 2:** ***How are the humans causing global warming?***

The primary reason for the increase in the greenhouse gases concentration is the extensive burning of fossil fuels and employment of fertilizers and pesticides in agriculture. The first group of charts represent the global $CO_2$ emissions by country, consumption of fertilizers since 1950, Timeline of $CO_2$ emissions of top polluting countries.

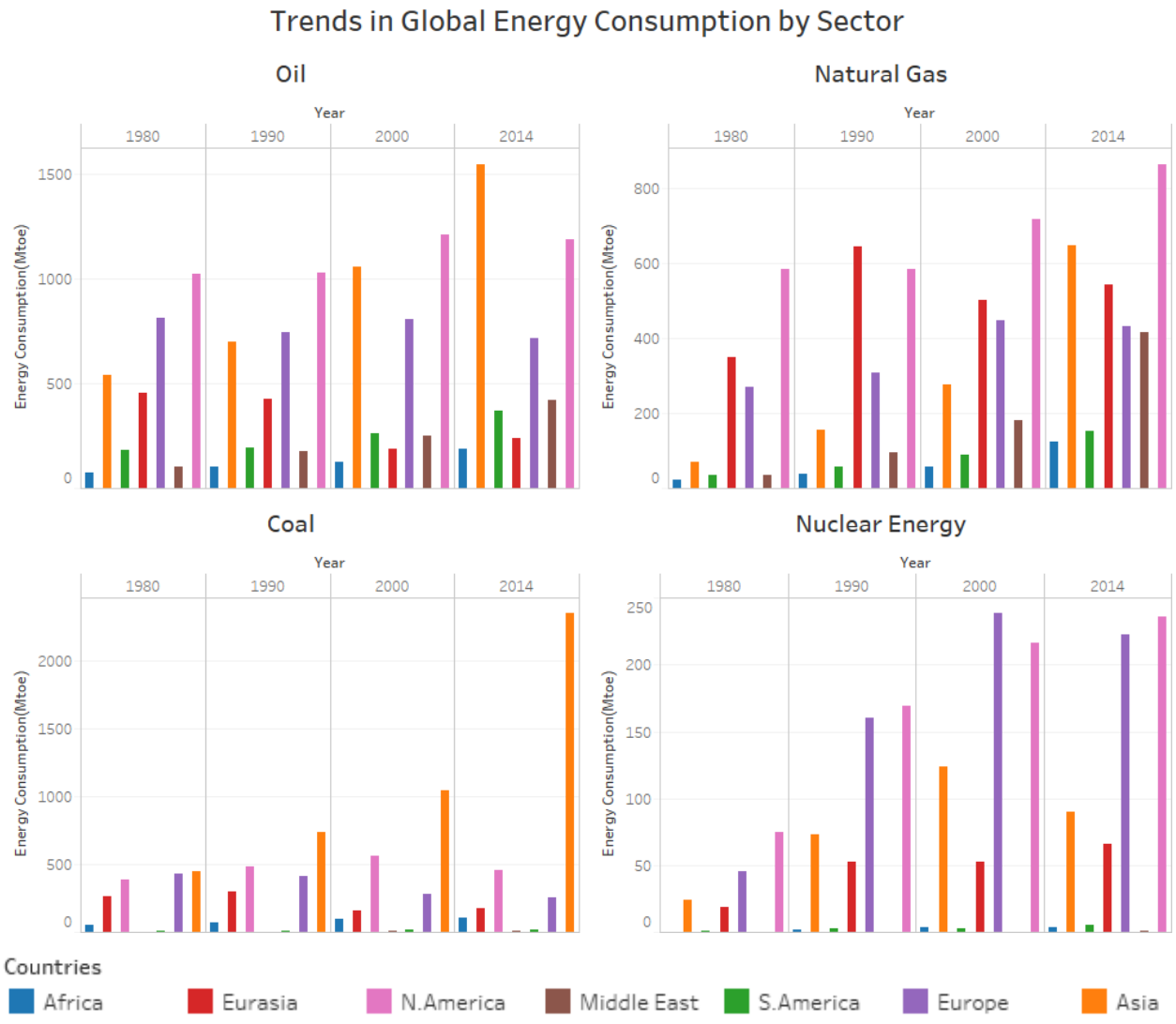



The filled map indicates that china has the major part in emissions of $CO_2$ (10,641,789 Kilotons) and is followed by United States, Russia and India . The second plot shows the rise in consumption of fertilizers post 1960 which explains the rise in nitrous oxide levels in atmosphere.

Looking at the history of emissions from fossil fuels plot, we can notice that China has been the major polluter which is closely followed by United States. It is evident that burning of fossil fuels has the major share in rise of $CO_2$ levels.




The above series of plots represent the energy consumption by the usage of Oil, Natural Gas, Coal and Nuclear energy respectively across the globe.

There is an increasing trend for consumption of oil, natural gas and coal in Asia, this explains the reason behind China being the major polluter.

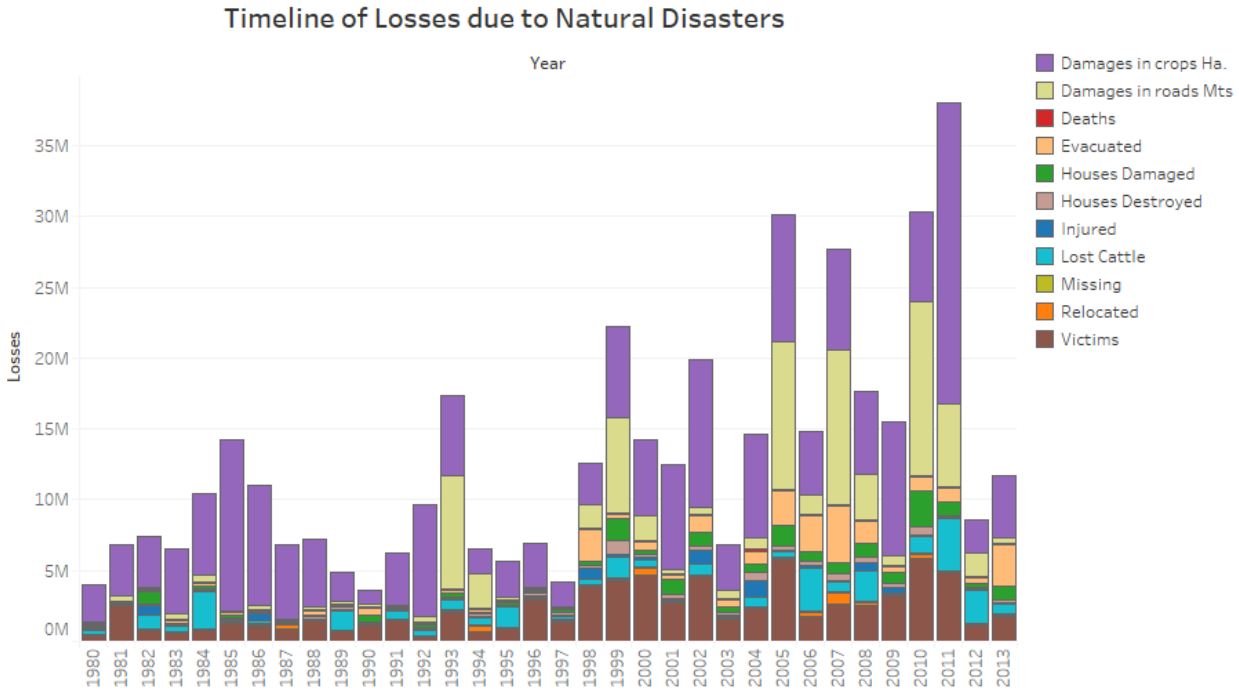
For North America and Europe, there is a rapid rise in the nuclear energy consumption, Although, it is less harmful than fossil fuels, the power plants release large amount of steam and water

vapor whose temperature is higher than that of atmosphere. This results in increase of water vapor, which is a greenhouse gas in turn causing rise in atmospheric temperature.

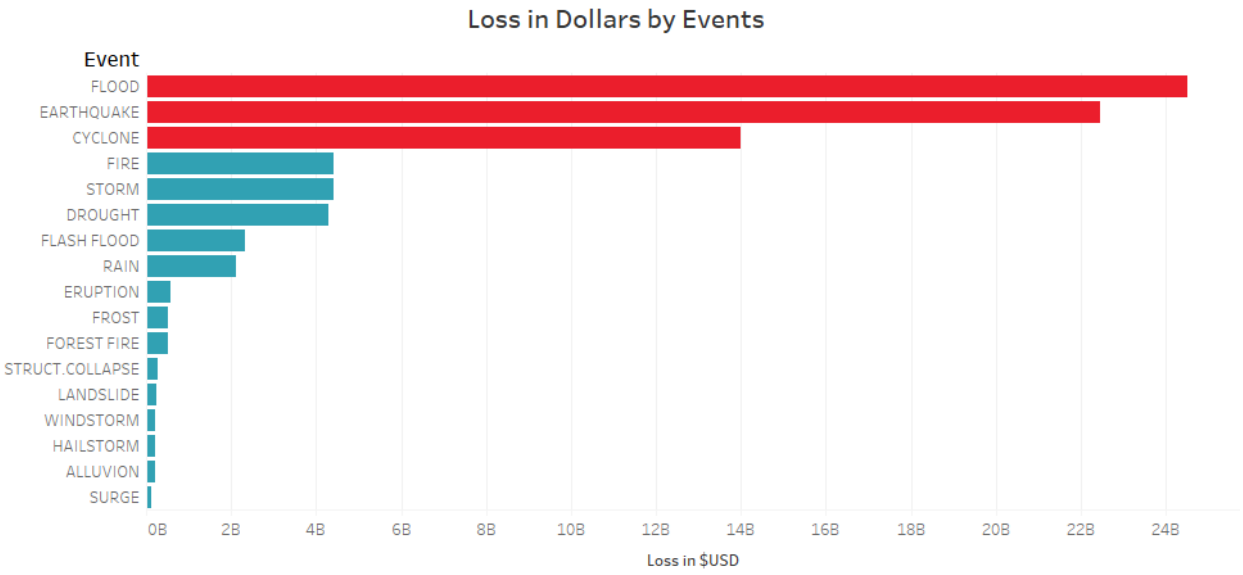
Middle eastern countries are heavily reliant on oil and natural gases. This is obvious because they extract and export oil and natural gases to other nations.

**Query 3:** ***What is the economic impact of global warming?***

The impact of global warming can be measured by the damages caused by the calamities that are caused due to adverse climatic changes. Melting polar ice can cause flooding in coastal areas, decrease in temperature difference between the poles and equator can attract major storms as the temperature is supposed to be greater at the equator than the poles. The strength of the storms is intensified by the water vapors in the atmosphere.




From the above graph, it is evident that crops have been affected more through the years. It is because of the flooding of the areas which not only damages the crops and roads but also decreases the fertility of soil by causing erosion. Shifting climatic patterns also affect crops by killing them either by heavy rainfall or by drought.




Above chart denotes the losses incurred in billions(USD) due to different catastrophic events. The events highlighted in red are Flood, Earthquake and Cyclone respectively causing the losses of approximately 24.5, 22.5 and 14 billion USD respectively form the most destructive events in terms of economic losses.

Although there is no direct correlation between these events and global warming, climatic variations which are caused by global warming is the reason for the occurrence of these events.

Cyclones might not directly be caused by global warming but can be intensified by the warming ocean waters which supply more energy for cyclone winds.

## Conclusion

There are various other factors such as change in migration patterns of birds, extinction of animal species, variation is climate patterns, reduction in forest cover, ozone layer depletion etc., which are due to the effect of global warming. An attempt is made to visualize the causes, evidences and effects of it. More efforts must be made to employ renewable sources of energies such as solar, wind, hydro and biomass to curb the greenhouse gas emissions and head towards a greener environment.

## Data Sources

Greenhouse Gases Concentration:

http://climate-energy-college.org/ghg-factsheets

Sea Level Rise:

https://climate.nasa.gov/vital-signs/sea-level/

Atlantic Ice Mass:

https://climate.nasa.gov/vital-signs/land-ice/

Surface Temperature:

https://climate.nasa.gov/vital-signs/global-temperature/

Ocean Temperature:

https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level

Losses Due to Disasters:

http://www.desinventar.net/DesInventar/profiletab.jsp?countrycode=g15&continue=y

Energy Consumption by Sector:

https://www.dropbox.com/s/7vg4l8uder3h7ha/TypeOfFOssil.xlsx?dl=0

Fertilizer Consumption:

https://www.quandl.com/data/EPI/211-World-Fertilizer-Consumption-1950-2009

Country-wise $CO_2$ Emissions in 2015:

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

$CO_2$ Emissions Timeline by Country:

http://cdiac.ornl.gov/trends/emis/tre_coun.html