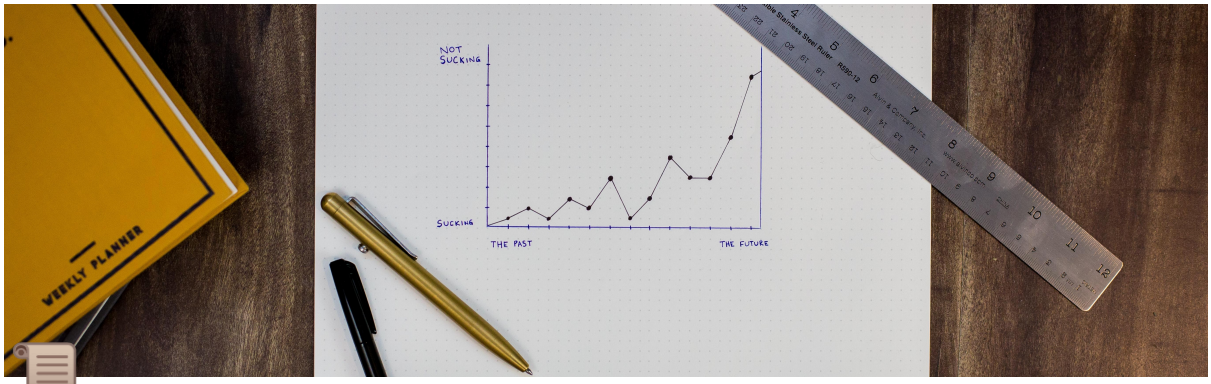


Summary Report

Problem Statement

Use space-based satellite data combined with ground observations to find the impact caused during the COVID-19 period

- Perform exploratory data analysis to find correlation between changes in the ground activities and impact on the environment
- Present a summary report on all your findings

I haven't taken all considerations but will try to update that in the future. I have mentioned points like improvements to be done, use of geospatial data etc.

Introduction

COVID-19 is one of the most deadliest pandemics that humanity has ever faced till now. As of now it has claimed 55.4 lakh people and counting...

There have been many rare events like lockdowns where the even the busiest cities became silent. Almost eerily quiet.

But there was one good news despite all this...

> Research says that this period of COVID-19 and lockdown has helped **reduce the speed of climate change**

So what is Climate Change?

Climate change refers to **long-term shifts in temperatures and weather patterns**. These shifts may be natural, such as through variations in the solar cycle.

But since the 1800s, human activities have been the main driver of climate change, primarily due to burning fossil fuels like coal, oil and gas.

> Research says that **95%** of the rapid increase in climate change is due to **human intervention**

Burning fossil fuels generates greenhouse gas emissions that act like a blanket wrapped around the Earth, trapping the sun's heat and raising temperatures.

Examples of greenhouse gas emissions that are causing climate change include **carbon dioxide and methane.** These come from using gasoline for driving a car or coal for heating a building, for example.

Clearing land and forests can also release carbon dioxide. Landfills for garbage are a major source of methane emissions. Energy, industry, transport, buildings, agriculture and land use are among the main emitters.

What does my project cover though?

I broke this project into 4 main parts:

1. Impact of COVID-19 on Air Quality
2. Impact of COVID-19 on Socio-Economic factors
3. Impact of COVID-19 on Water Quality(chlorophyll levels) factors

4. And impact of COVID-19 on Land Use (NDVI values)

I have used **India and parts of India(for land use)** as my **region of interest** for this project.

But before that, lets understand some things about COVID-19.

Analysing COVID-19 in India

What is COVID-19?

> Coronavirus disease (COVID-19) is an infectious disease caused by the SARS-CoV-2 virus.

Says WHO?

Yes WHO, the World Health Organization.

It is a type of virus that spreads through droplets and virus particles released into the air when an infected person breathes, talks, laughs, sings, coughs or sneezes.

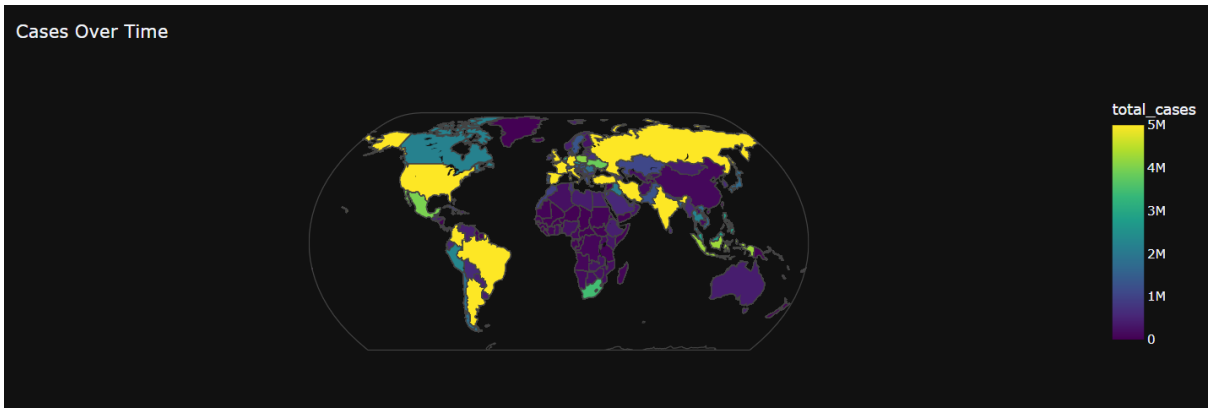
Larger droplets may fall to the ground in a few seconds, but tiny infectious particles can linger in the air and accumulate in indoor places, especially where many people are gathered and there is poor ventilation.

This is why mask-wearing, hand hygiene and physical distancing are essential to preventing COVID-19.

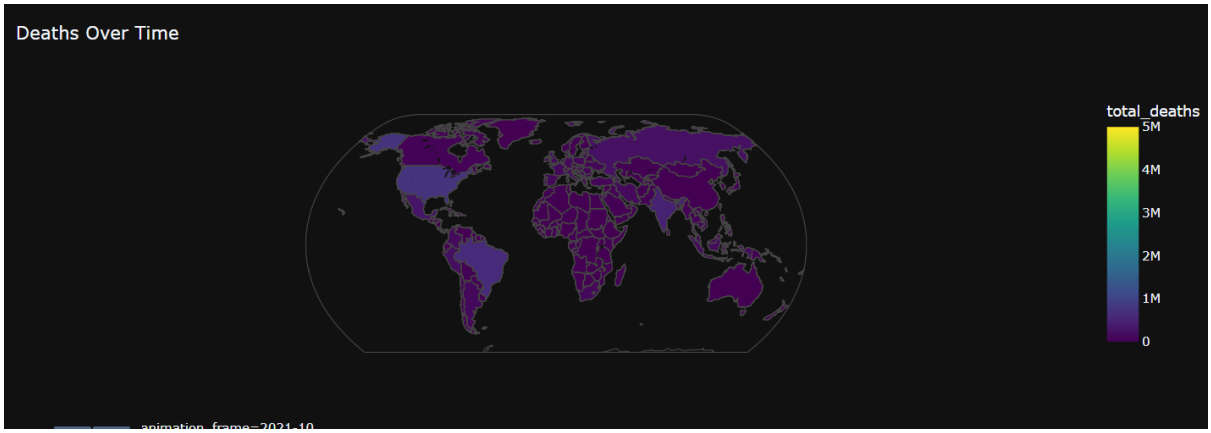
World on Spotlight

These are screenshots of my EDA on COVID-19. They are statistics counted in millions

Cases Visualized



Deaths Visualized



Timeline of COVID-19 in India

India caught the COVID-
19 pandemic quite early. It is probably due to the fact that India has a large number of NRIs and travellers who frequently return

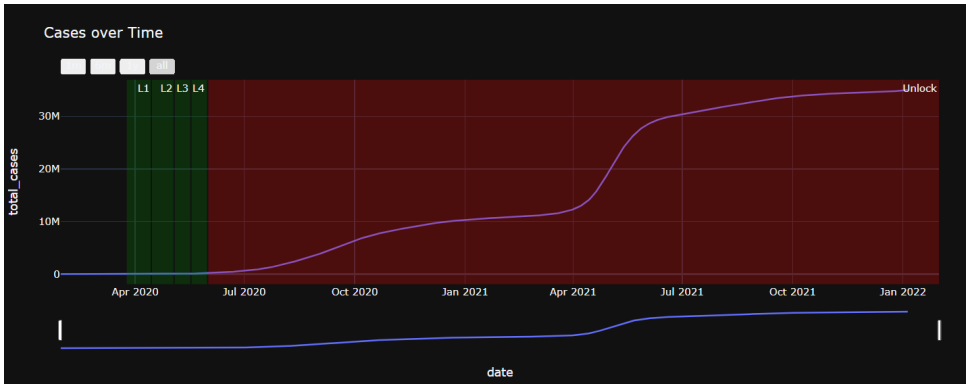
In fact, it was a 20 year old Female who had returned to India from Wuhan, China (where the pandemic had started).

Event	Date of Event
First Confirmed Case	27th January 2020
First Confirmed Death	12th March 2020
Lockdown Phase 1	25th March 2020 - 14th April 2020
Lockdown Phase 2	15th April 2020 - 3rd May 2020
Lockdown Phase 3	4th May 2020 - 17th May 2020
Lockdown Phase 4	18th May 2020 - 31st May 2020
Unlock 1.0	1th June 2020 - 30th June 2020
Unlock 2.0	1th July 2020 - 31st July 2020
Unlock 3.0	1st August 2020 – 31st August 2020
Unlock 4.0	1st September 2020 - 30th September 2020
Unlock 5.0	1st October 2020 - 31st October 2020
Unlock 6.0	1st November 2020 - 30th November 2020
Unlock 7.0	1st December 2020 - 31st December 2020
Unlock 8.0	1st January 2021 - 31st January 2021
Unlock 9.0	1st February 2021 - 28th February 2021
Unlock 10.0	1st March 2021 - 31st March 2021
Unlock 11.0	1st April 2021 - 30th April 2021
Unlock 12.0	1st May 2021 - 31st May 2021
Unlock 13.0	1st June 2021 - 30th June 2021
Unlock 14.0	1st July 2021 - 31st July 2021
Unlock 15.0	1st August 2021 - 31st August 2021
Unlock 16.0	1st September 2021 - 30th September 2021
Unlock 17.0	1st October 2021 - 31st October 2021
Unlock 18.0	1st November 2021 - 30th November 2021
Unlock 19.0	1st December 2021 - 31st December 2021
Unlock 20.0	1st January 2022 - 31st January 2022

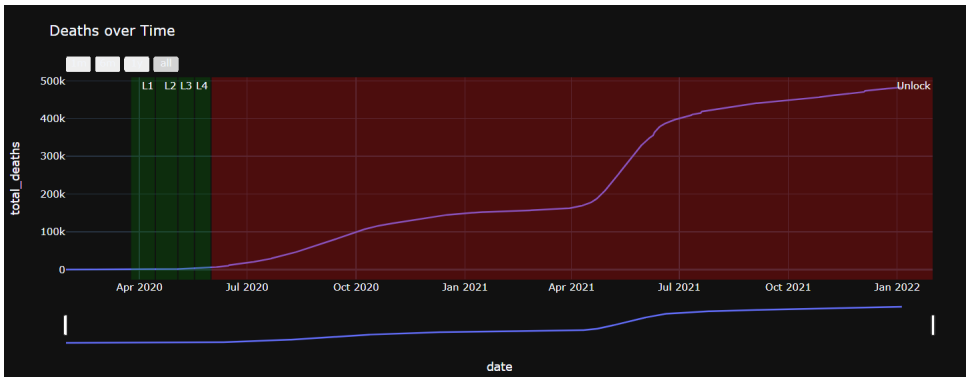
As of now, we are in the 20th iteration of the Unlock Timezone.

Some Statistics on India

Time series plot on COVID-19 cases



Time Series plot on the COVID-19 deaths



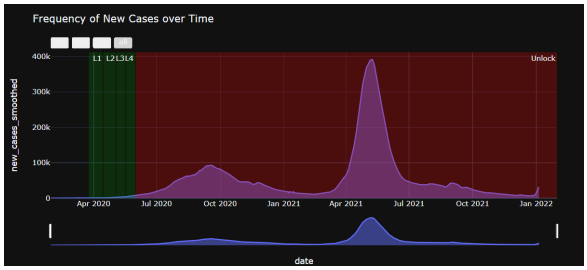
Green areas = Lockdown Periods

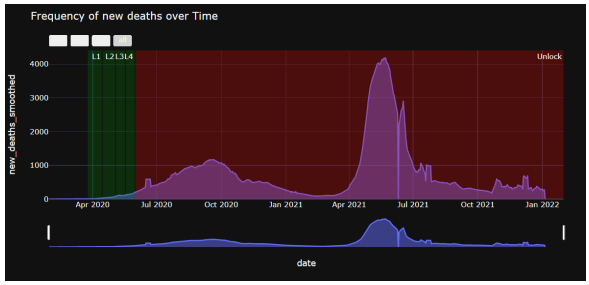
Red areas = Unlock Periods

By taking a glance at the graph, we can come up with some conclusions:

1. The lockdowns did a very good job of containing the number of cases and deaths
2. But it would be better in the terms of reduction if we had continued the lockdown even for the week throughout this stage

But let's take at daily numbers shall we?





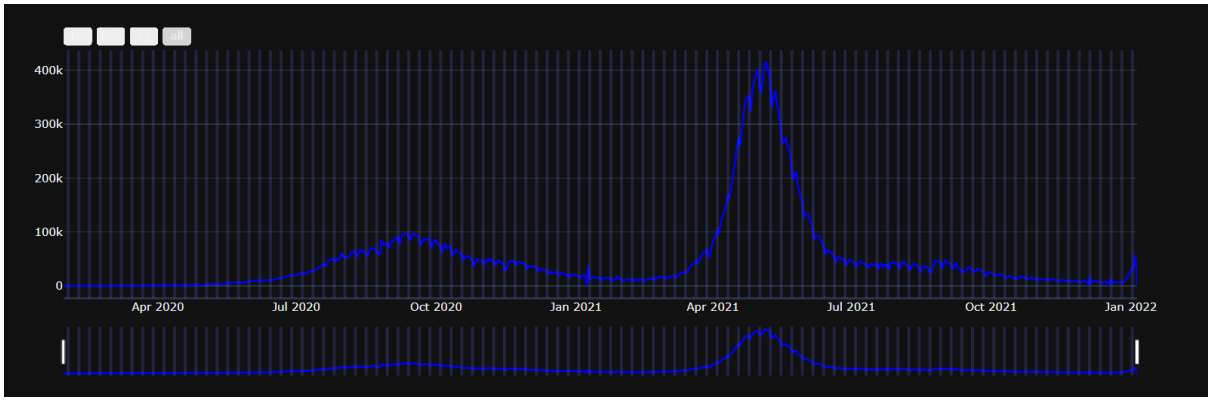
So, here we just emphasis the above conclusions we made earlier. But it is understandable that the government chose not to opt for a nation-wide lockdown because it could take a huge hit on our economy which we will analyse later.

Do weekend lockdowns work?

Many regions like Jammu and Kashmir, Rajasthan, Delhi have recently imposed weekend lockdowns to curb the increase in the cases and recently emerged Omicron variant of COVID-19.

The question has to be asked, is imposing a weekend lockdown any good?

Lets take a look at the data of daily cases through time with emphasis on the weekends



The highlighted regions in the graph are weekends

So, by taking a look, we can see a decrease in the number cases after weekends. It is surprising to see that the number of cases decrease after the weekends! Even when there were no weekend lockdowns!

Maybe due to fact that we are happy in our weekends and that raises our immunity ;)

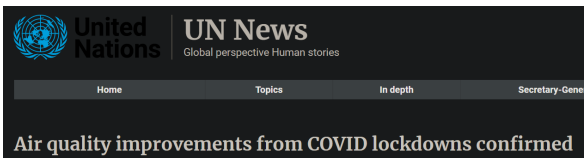
So, now we can say

> 💡 Weekend Lockdowns work quite well actually. Scratch that, weekends decrease the number of cases! That's probably why many countries are thinking about a 4 day work week.

#The other insights are work in progress

Impact of COVID-19 on Air Quality

There have been many reports regarding the improvement in air quality during the lockdown period in India.



The above some of the recent ones that support the research.

But let's see that for ourselves

How is Air Quality Measured?

Air Quality is a measure of how clean or polluted the air is. Monitoring air quality is important because polluted air can be bad for our health—and the health of the environment.

- Air Quality is measured with the Air Quality Index(AQI).
- It works like a thermometer that runs from 0 to 500 degrees

The air in our atmosphere is mostly made up of two gases that are essential for life on Earth:

- Nitrogen
- Oxygen

However, the air also contains smaller amounts of many other gases and particles.

AQI tracks five major air pollutants:

1. Ozone
2. Carbon Monoxide
3. Sulphur Dioxide
4. Nitrogen Dioxide
5. Airborne particles, or aerosols (work in progress)

Here I have experimented with 4 of these and some minor pollutants

AQI Scale

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health alert: everyone may experience more serious health effects.
Hazardous	301 to 500	Health warnings of emergency conditions. The entire population is more likely to be affected.

Timelines

I have considered three main timelines for visual analysis:

1. Pre-COVID = 25th March 2019 - 25th April 2019
2. COVID Lockdown Period = 25th March 2020 - 25th April 2020
3. Unlock Period = 25th March 2021 - 25th April 2021

I have used these days for comparisons

For most of the analysis, I have used Level 3 monthly data products of European Space Agency (EESA)'s Sentinel 5p satellite. I was fed up with experimenting and failing to properly analyse Level 2 data due to its sheer number of internal files. The level 2 products were in NetCDF format which gave me problem because I could convert it to GeoTiff for analysis even after trying with Python and GDAL.

The Level 3 products have been introduced in the Google Earth Engine's Datasets by EESA and not anywhere else for some reason (weird)..

- They have used `harpconvert` for this task.

I have used GEE to extract data in GeoTiff format and then I have clipped to mask of the India's Shapefile with QGIS. I just wanted to use QGIS in some manner so..

Impact on Ozone

Sentinel-5P OFFL O3: Offline Ozone | Earth Engine Data Catalog | Google Developers

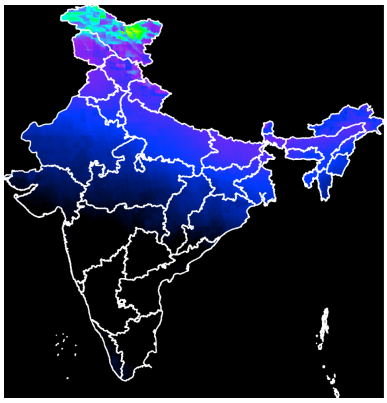
What is Ozone?

> Ozone is a gas composed of three atoms of oxygen. Ozone occurs both in the Earth's upper atmosphere and at ground level. Ozone can be good or bad, depending on where it is found.
>
> Called stratospheric ozone, good ozone occurs naturally in the upper atmosphere, where it forms a protective layer that shields us from the sun's harmful ultraviolet rays. This beneficial ozone has been partially destroyed by manmade chemicals, causing what is sometimes called a "hole in the ozone." (good news that it is diminishing! saw it in vox video)
>
> Ozone at ground level is a harmful air pollutant, because of its effects on people and the environment, and it is the main ingredient in "smog."

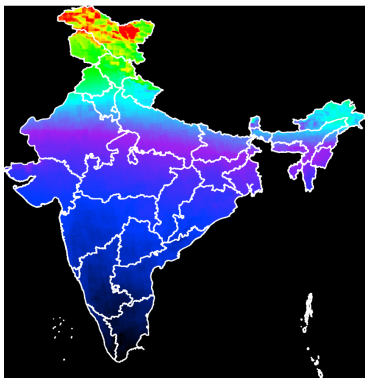
What creates Ground Level Ozone?

- It forms **when heat and sunlight allow the reaction of two other pollutants**: nitrogen oxides and volatile organic compounds.
- These chemicals come from industrial plants, electric utilities, vehicle exhaust, wildfire smoke, and oil and gas extraction.
- High heat can accelerate this process

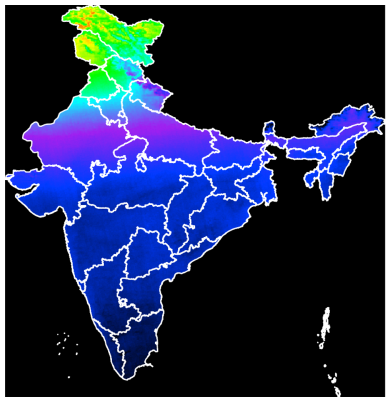
Now show me the results..



Ozone 2019



Ozone 2020



Ozone 2021

So what's the conclusion here?

There is a big change in Ozone through the years but the good news is that has reduced when we look at 2021. That means, we are making progress.

Why is it showing such a result in March-April 2020 is yet to be understood by me.

Impact on Carbon Monoxide

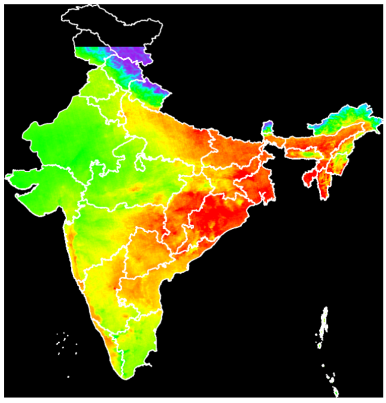
Sentinel-5P OFFL CO: Offline Carbon Monoxide | Earth Engine Data Catalog | Google Developers

Carbon monoxide (CO) is a clear, odourless gas. Smoke and exhaust fumes often contain carbon monoxide.

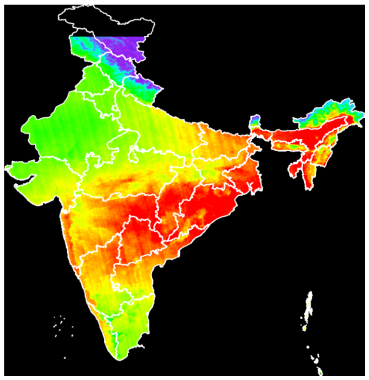
Carbon monoxide is a common air pollutant.

Carbon monoxide forms when materials don't burn completely. Sources of carbon monoxide can include:

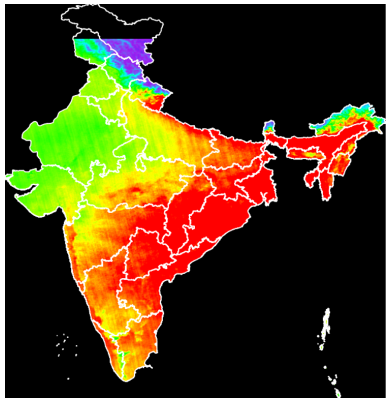
- burning fossil fuels like natural gas, petrol, coal and oil
- **wood smoke**
- **car and truck exhausts**
- faulty gas heaters, BBQs, ovens, and cooktops.



2019 CO



2020 CO



2021 CO

Please don't mind the black area on J&K, it's just that the clipping of India on that region was giving me bad results

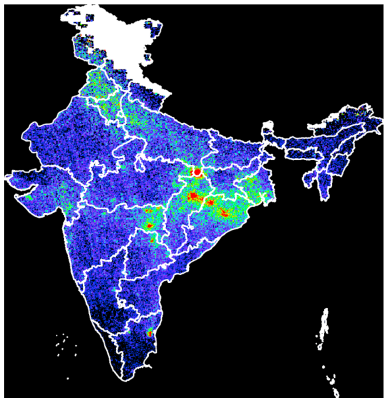
There has been an increase in the carbon monoxide levels by early analysis

Impact on Sulphur Dioxide

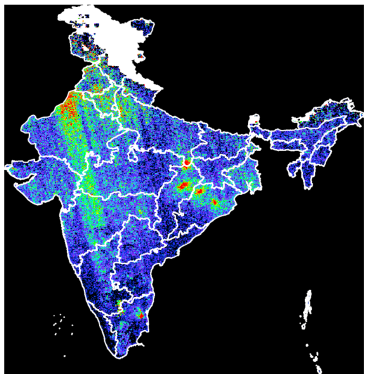
Sentinel-5P OFFL SO2: Offline Sulphur Dioxide | Earth Engine Data Catalog | Google Developers

Sulfur dioxide (SO2) is a gaseous air pollutant composed of sulfur and oxygen. SO2 forms when sulfur-containing fuel such as coal, oil, or diesel is burned. Sulfur dioxide also converts in the atmosphere to sulfates.

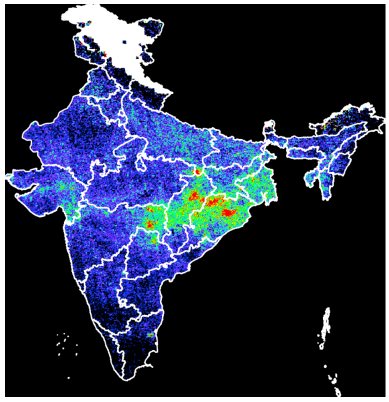
The largest sources of sulfur dioxide emissions are electricity generation, industrial boilers, and other industrial processes such as petroleum refining and metal processing. Diesel engines are another major source, including old buses and trucks, locomotives, ships, and off-road diesel equipment.



2019 SO2



2020 SO2



2021 SO2

There is no special change in early analysis. The line of increase in SO2 could be due to the fact that Sentinel 5p stops on search path at that pace.

But there is an increase

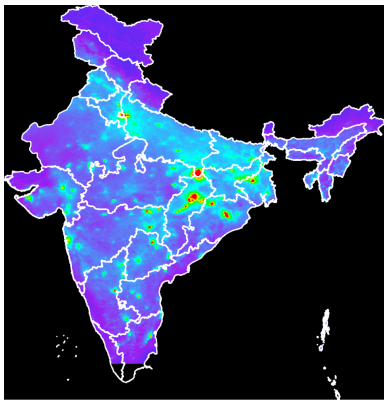
Impact on Nitrogen Dioxide

Sentinel-5P OFFL NO2: Offline Nitrogen Dioxide | Earth Engine Data Catalog | Google Developers

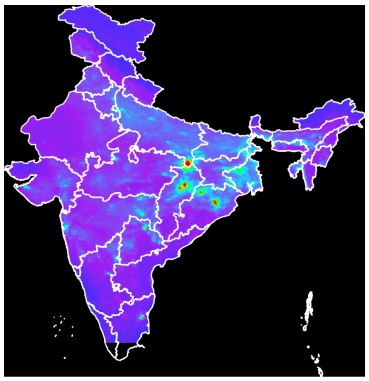
Nitrogen dioxide, or NO2, is a gaseous air pollutant composed of nitrogen and oxygen and is one of a group of related gases called nitrogen oxides, or NOx. ..

NO2 forms when fossil fuels such as coal, oil, gas or diesel are burned at high temperatures. NO2 and other nitrogen oxides in the outdoor air contribute to particle pollution and to the chemical reactions that make ozone

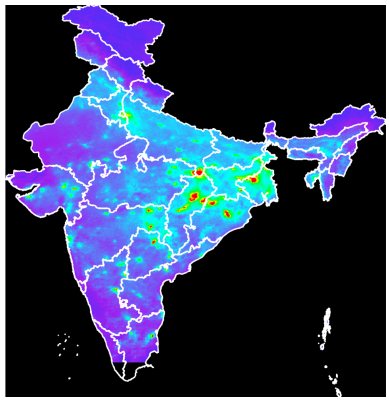
Cars, trucks, and buses are the largest sources of emissions, followed by power plants, diesel-powered heavy construction equipment and other movable engines, and industrial boilers.



2019 NO2



2020 NO2



2021 NO2

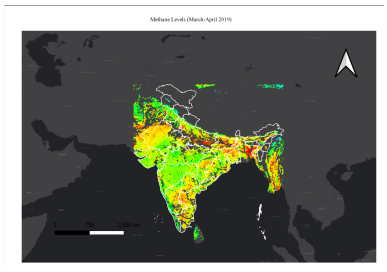
Most of the news reports show this improvement. It is really beautiful to see a decrease but there is an increase afterwards

Impact on Methane

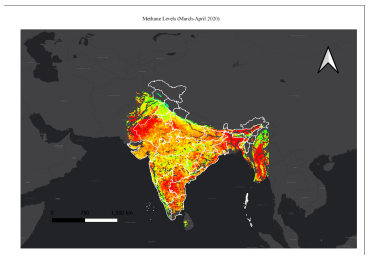
Sentinel-5P OFFL CH4: Offline Methane | Earth Engine Data Catalog | Google Developers

Methane is the primary contributor to the formation of ground-level ozone, a hazardous air pollutant and greenhouse gas, exposure to which causes 1 million premature deaths every year. Methane is also a **powerful** greenhouse gas.

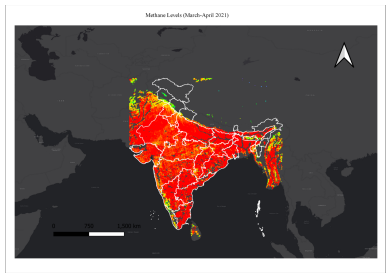
Methane is emitted from a variety of anthropogenic (human-influenced) and **natural sources**. Anthropogenic emission sources include landfills, oil and natural gas systems, agricultural activities, coal mining, stationary and mobile combustion, wastewater treatment, and certain industrial processes.



2019 CH4



2020 CH4



2021 CH4

I tried making a formal map for a change, its not clear is it?

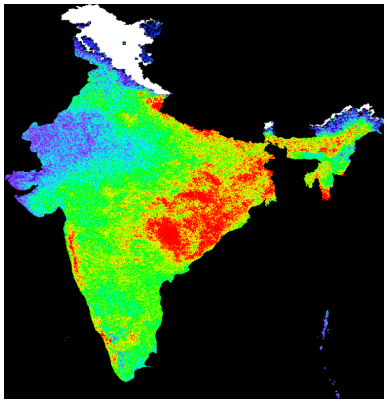
There is an increase in early analysis

Impact on Formaldehyde

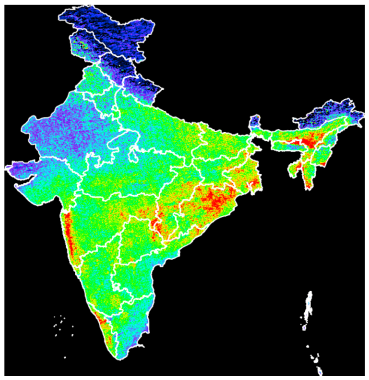
Sentinel-5P OFFL HCHO: Offline Formaldehyde | Earth Engine Data Catalog | Google Developers

Formaldehyde is a **common** indoor air pollutant. It is a gas that can irritate a person's eyes, nose, throat, and lungs, or trigger an asthma attack, even at low concentrations. Prolonged exposure to formaldehyde can cause cancer.

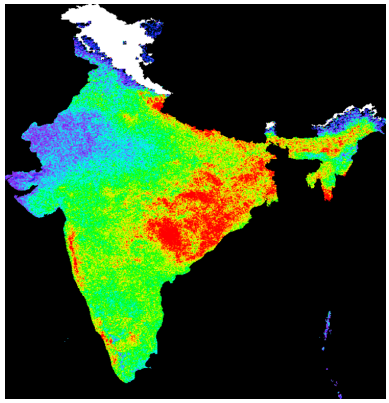
Sources of formaldehyde in the home include **building materials, smoking, household products**, and the use of un-vented, fuel-burning appliances, like gas stoves or kerosene space heaters. Formaldehyde, by itself or in combination with other chemicals, serves a number of purposes in manufactured products



CH2O 2019



CH2O 2020



CH2O 2021

There is a decrease in 2020 but rises again in 20

What about Air Quality in Ground Level Sensors?

I took Colaba, Mumbai as a reference point for this.

Ground sensors are always more accurate in terms of the recording data.

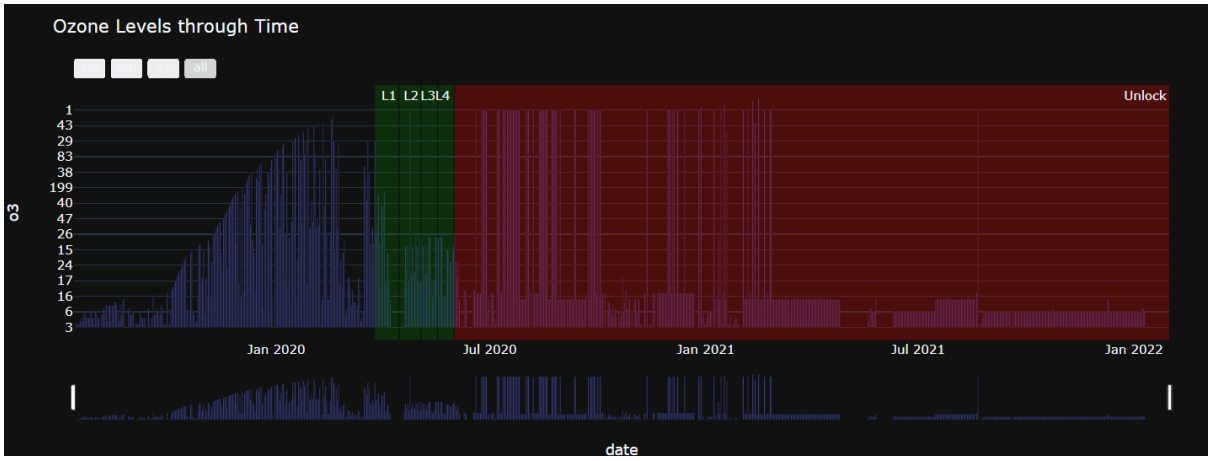
But they can be expensive and also low in number

Which is why they are being used as accuracy assessment for satellite bound data

So again we are going to take data from different pollutants

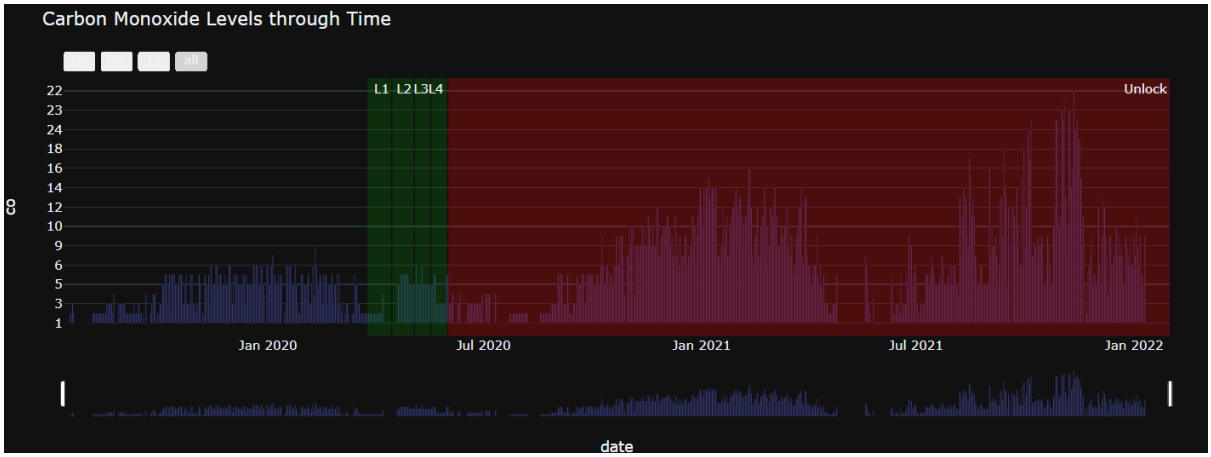
1. Ozone
2. Carbon Monoxide
3. Sulphur Dioxide
4. Nitrogen Dioxide
5. Airborne particles, or aerosols

Impact on Ozone



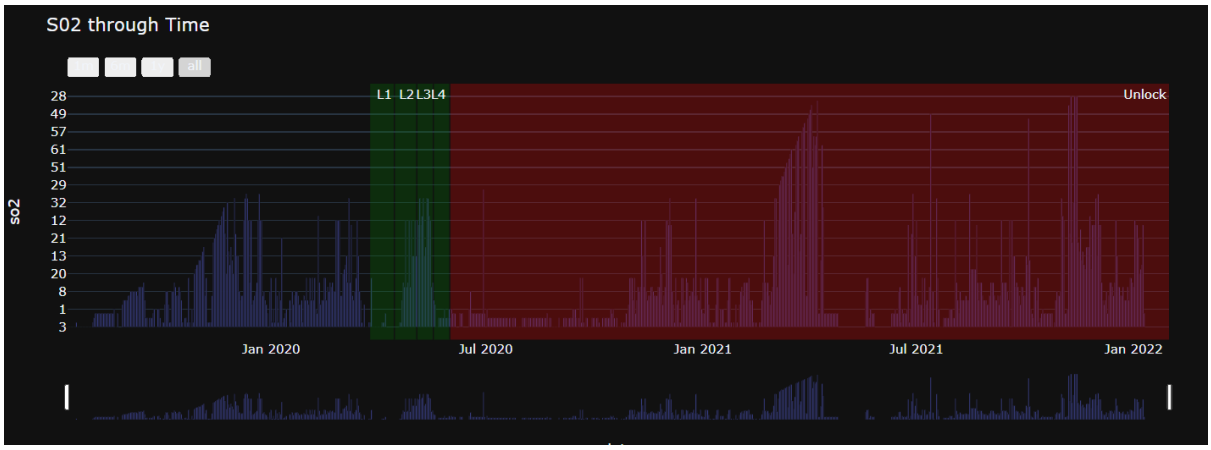
There is a decrease in during the lockdown here.

Impact on Carbon Monoxide



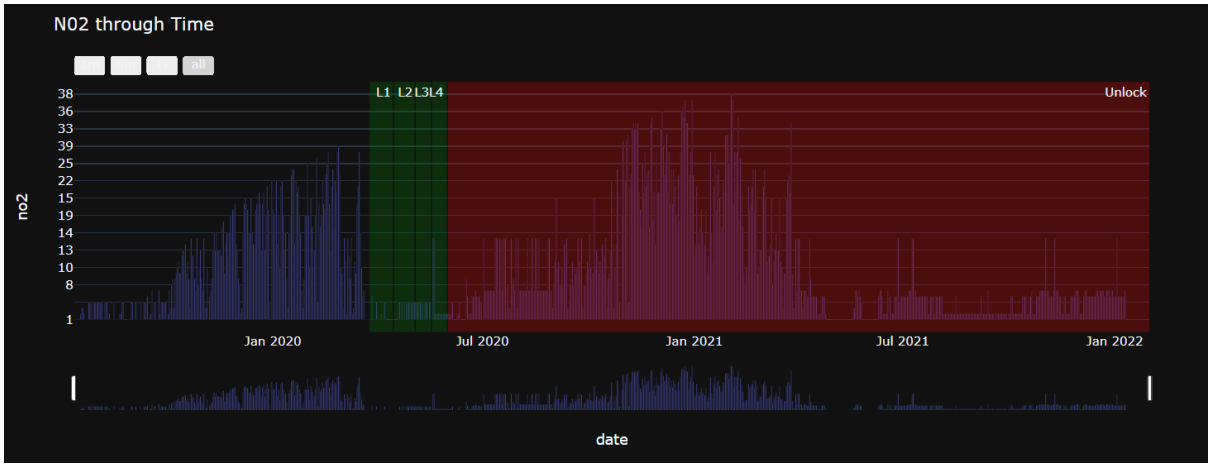
Carbon Monoxide surprisingly is stable here but goes out of control in the unlock period

Impact on Sulphur Dioxide



Quite similar to Carbon Monoxide

Impact on Nitrogen Dioxide

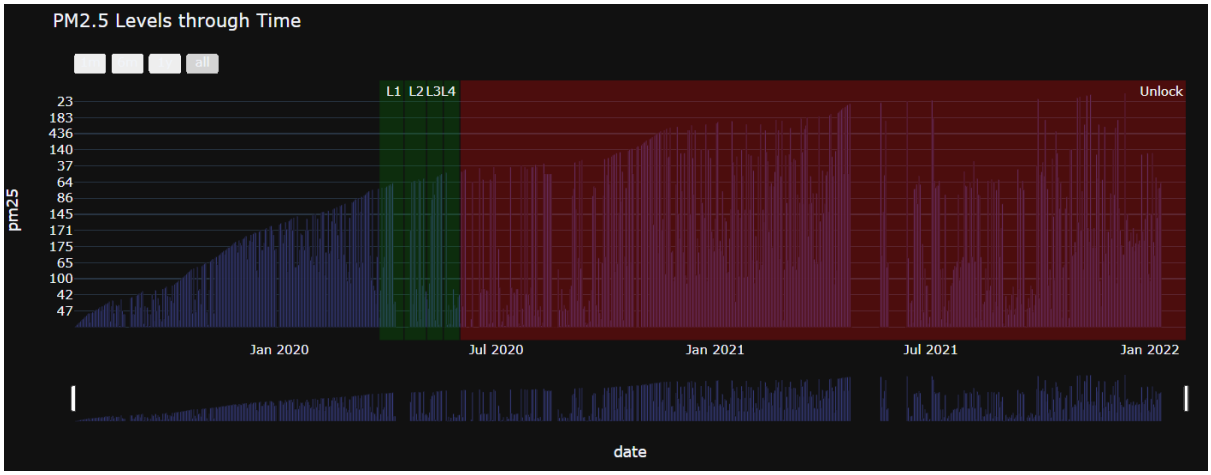


Now, this is what I am talking about!

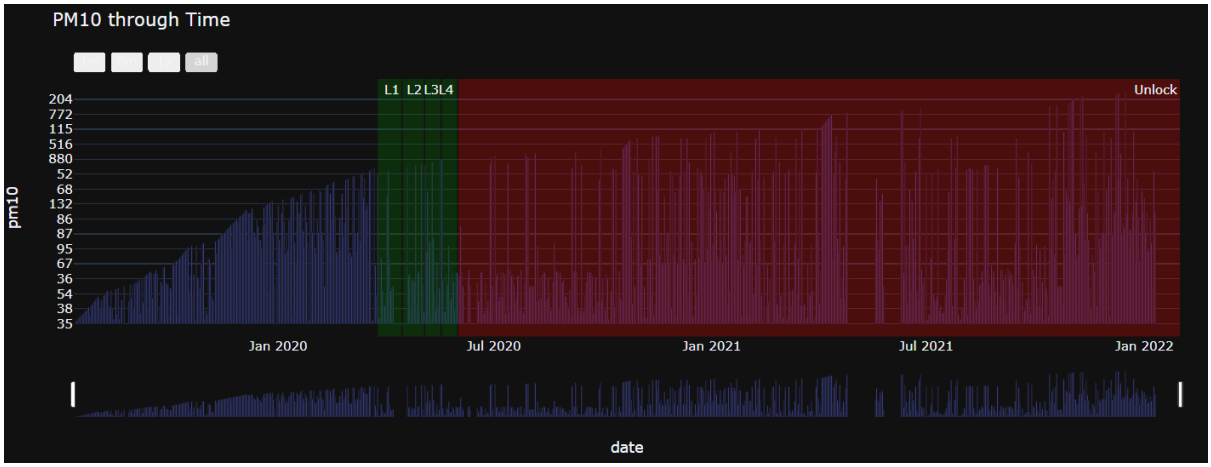
What an improvement in the lockdown period! But to my dismay, it increases again in the unlock period

Impact on Airborne Particles

PM2.5



PM10



This is very good because there is a steady rise here.

So let’s move forward towards a different indicator.

Impact on Socio-Economic Indicators

Socioeconomics (also known as **social economics**) is the social science that studies how economic activity affects and is shaped by social processes. In general it analyzes how modern societies progress, stagnate, or regress because of their local or regional economy, or the global economy. Societies are divided into three groups: social, cultural and economic.

It also refers to the ways that social and economic factors influence the economy.

The indicators that I have considered as of now are:

1. GDP
2. Unemployment
3. Export-Import Ratio
4. Private Fuel Consumption
5. Car Registrations - Sales
6. Total Whole Prices by Industry Aggregate
7. Consumer Price Index
8. BSE Sensex
9. NSE Nifty

More indicators will be added in the future.

BSE Sensex

S&P BSE SENSEX (^BSESN) Charts, Data & News - Yahoo Finance

The **BSE SENSEX** (also known as the S&P Bombay Stock Exchange **Sens**itive Ind**ex** or simply **SENSEX**) is a free-float market-weighted stock market index of 30 well-established and financially sound companies listed on the Bombay Stock Exchange.

The 30 constituent companies which are some of the largest and most actively traded stocks, are representative of various industrial sectors of the Indian economy.

So by looking at the candlestick plot, we get an idea of how did the stock market perform during the COVID-19 Period

We see a decline that starts in month of January that increases till March but starts to make a recovery after that.

It's good to see that we have become stronger after the lockdown.

NSE Nifty

NIFTY 50 (^NSEI) Charts, Data & News - Yahoo Finance

The **NIFTY 50** is a benchmark Indian stock market index that represents the weighted average of 50 of the largest Indian companies listed on the National Stock Exchange.

It is one of the two main stock indices used in India, the other being the BSE SENSEX.

There is a similar trend with Nifty as well

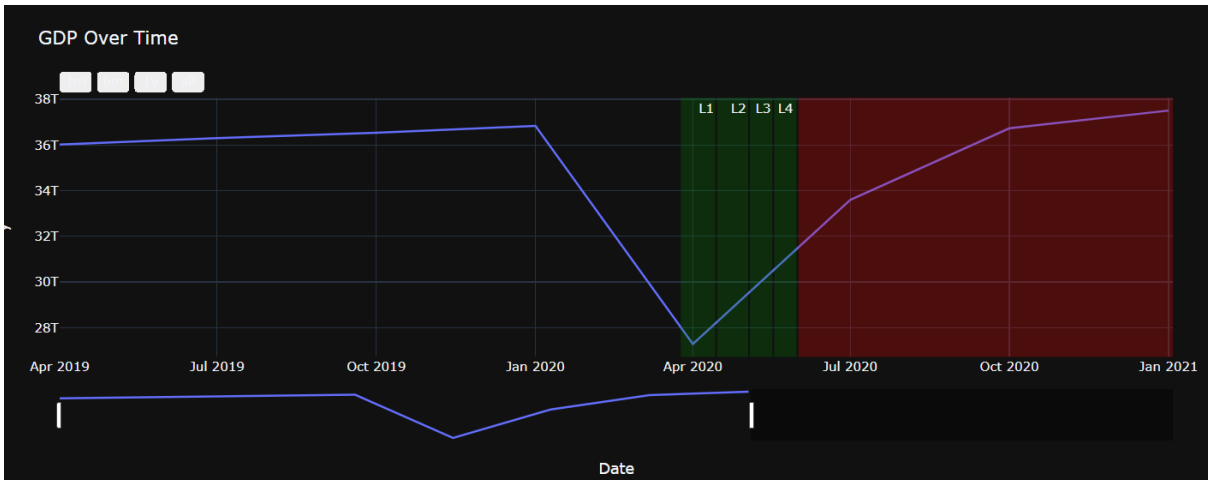
GDP

Gross domestic product (GDP) is the total monetary or market value of all the finished goods and services produced within a country's borders in a specific time period. As a broad measure of overall domestic production, it functions as a comprehensive scorecard of a given country's economic health.

Though GDP is typically calculated on an annual basis, it is sometimes calculated on a quarterly basis as well.

Here I have plotted GDP over quarterly basis till the period of Jan 2021.

I will be updating updated GDP data when available

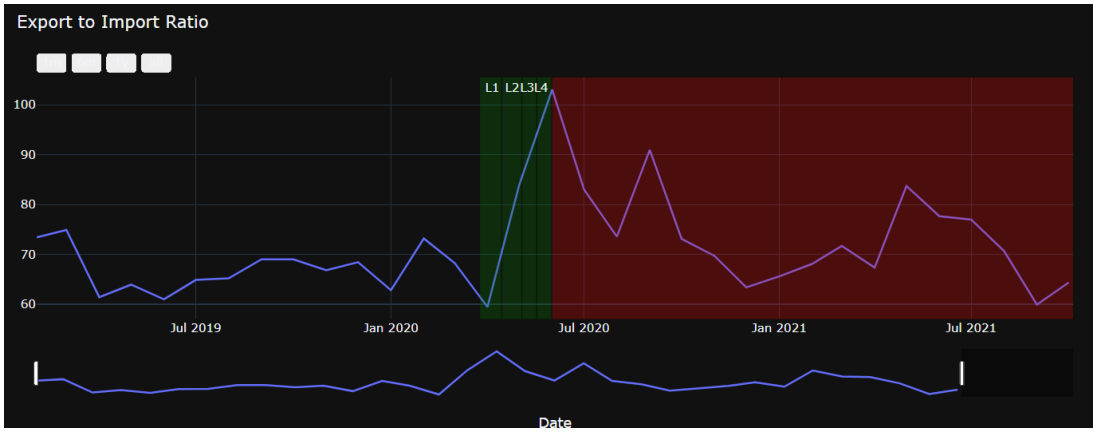


Here we can see a steep decline during start of 2020, probably due to COVID-19. But there is good recovery as the time passes.

Export-Import Ratio Over Time

Ratio of Exports to Imports for India (XTEITT01INM156N) | FRED | St. Louis Fed (stlouisfed.org)

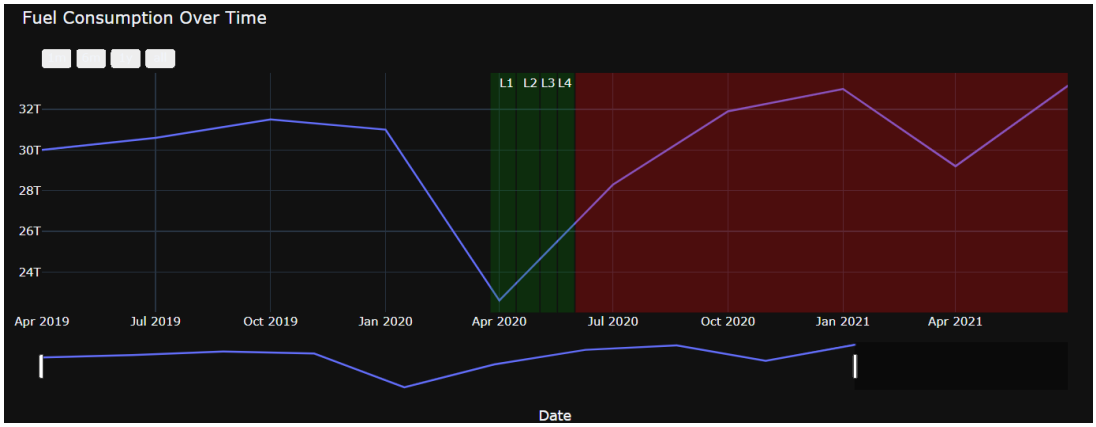
Export-import ratio refers to the **ratio** of the value of exported goods and services to imported goods and services of the countries involved in international trade. An improvement of a nation **export-import ratio** benefits that country in the sense that it can have more export than its value of imports.



We see a huge increase in the export-import ratio during the times of lockdown. It was probably due to the fact that India was exporting quite a lot of goods during these times.

But we do see a decrease again after in the following months

Private Fuel Consumption

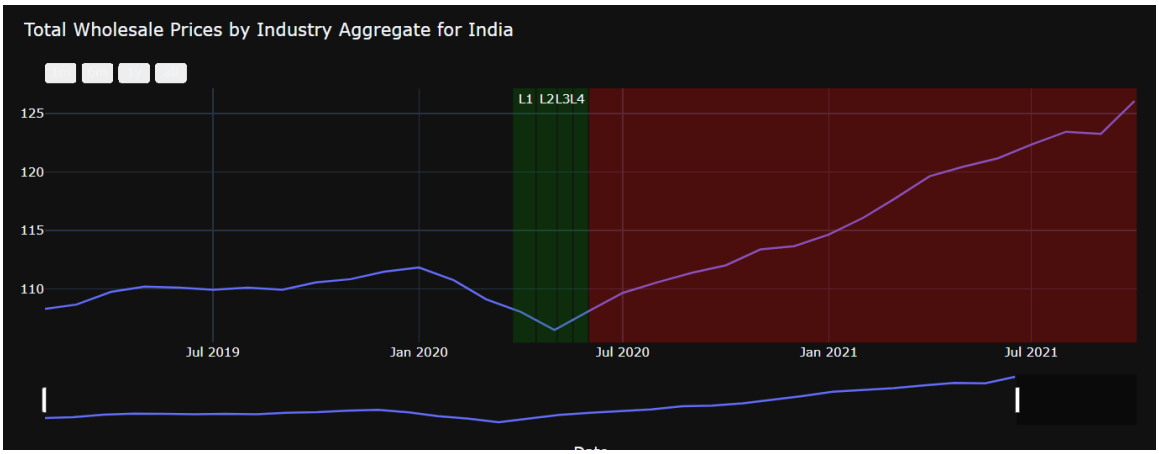


If we are talking about transport industry, we have to talk about private fuel consumption. It is really staggering to see such a fall in the consumption in the lockdown.

It might be a huge loss to the business dealing with fuel but it has considerable helped the nation to breathe

Total Wholesale Prices by Industry Aggregate

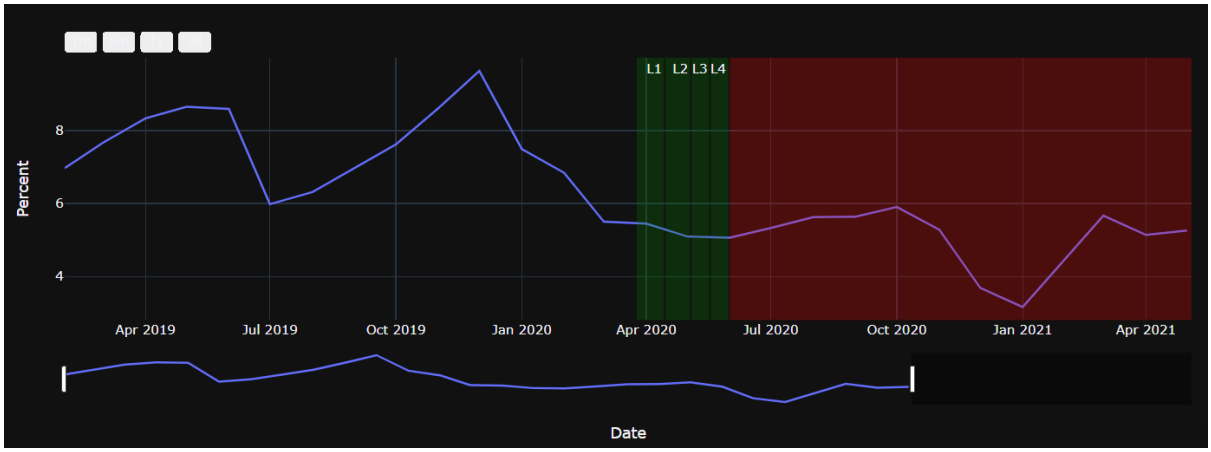
A wholesale price index (WPI) is an index that measures and tracks the changes in the price of goods in the stages before the retail level. This refers to goods that are sold in bulk and traded between entities or businesses (instead of between consumers). Usually expressed as a ratio or percentage, the WPI shows the included goods' average price change



This too saw a decrease in the lockdown period. The price that goods were sold in bulk were probably the reason for some industries to flourish but also at the same time go bankrupt

Consumer Price Index

A **consumer price index** (**CPI**) is a price index, the price of a weighted average market basket of consumer goods and services purchased by households. Changes in measured CPI track changes in prices over time

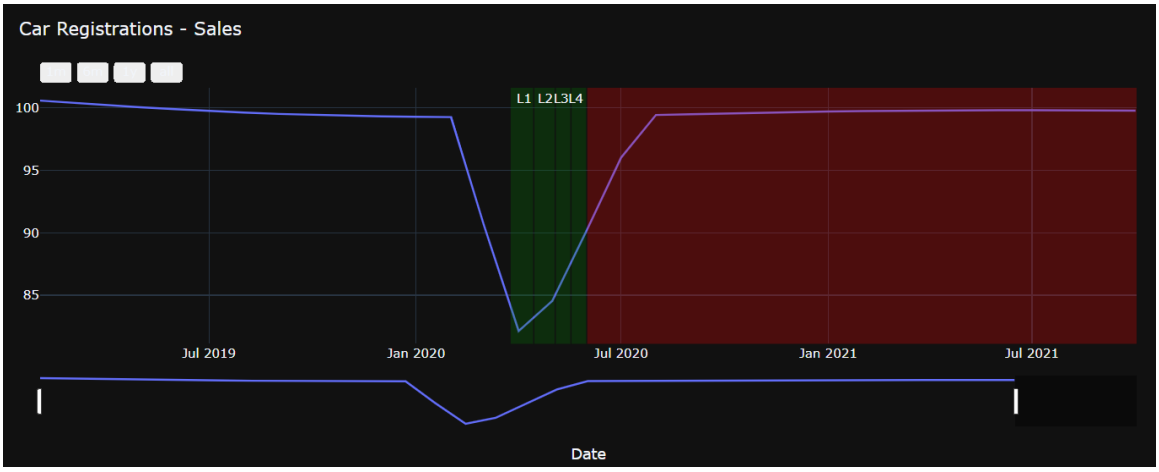


Things got cheaper due to customers not panic shopping.

It stayed at a constant rate but falling more during the start of 2021. But also recovered afterwards

Car Registrations - Sales

The fall in the number of cars sold was almost catastrophic to see.

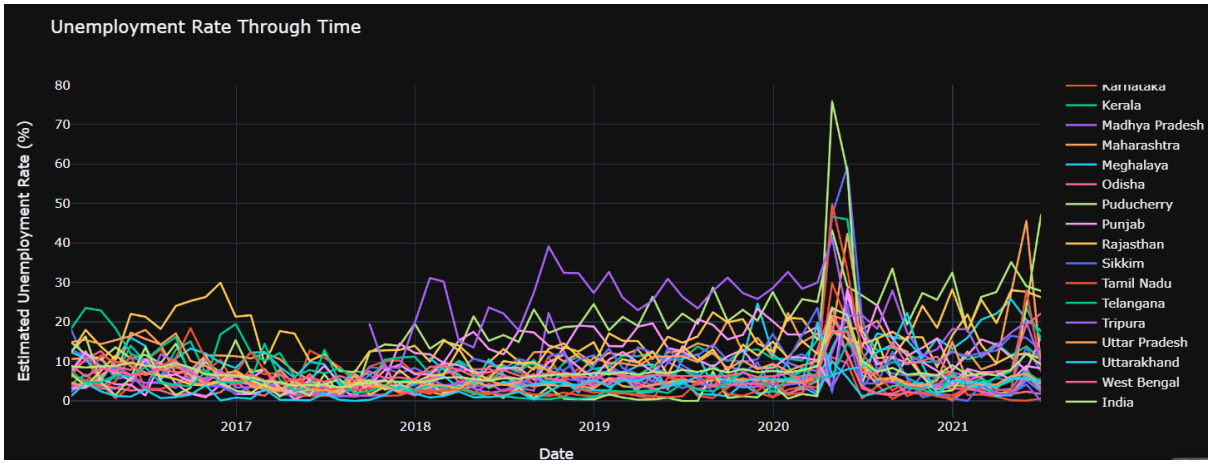


Due to reasons like COVID-19, there was an added disadvantage to chip shortage causing the further decline of the car industry.

But it regained it lost pace back at the unlock stages

Unemployment

Unemployment is a term referring to individuals who are employable and actively seeking a job but are unable to find a job. Included in this group are those people in the workforce who are working but do not have an appropriate job. Usually measured by the unemployment rate, which is dividing the number of unemployed people by the total number of people in the workforce, unemployment serves as one of the indicators of a country's economic status.

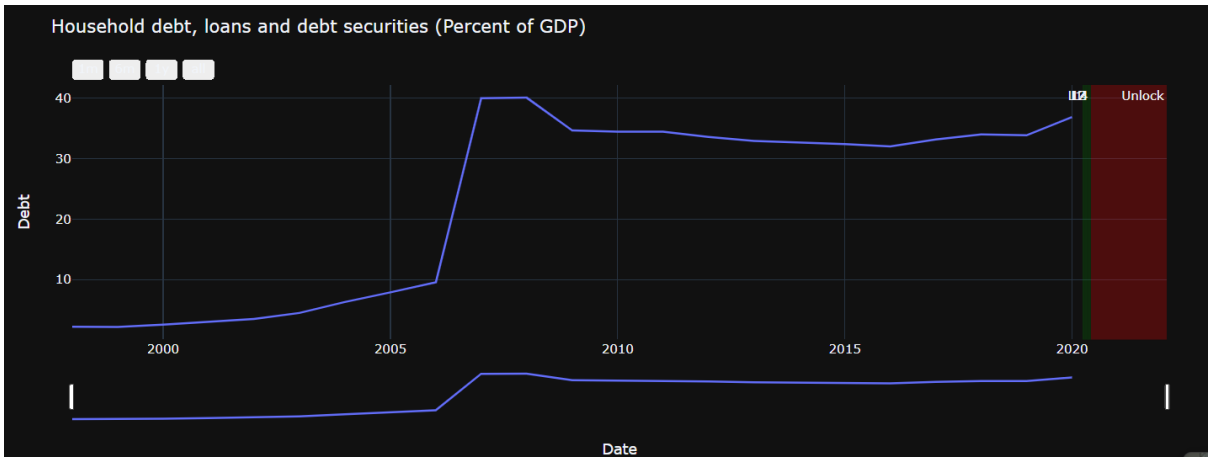


India saw a rapid increase in unemployment during the period of lockdown, and some months thereafter. This can be seen by the sudden spike during the months of 2020.

Household debt

I didn't get the updated figures of household debt in the year of 2020, and 2021

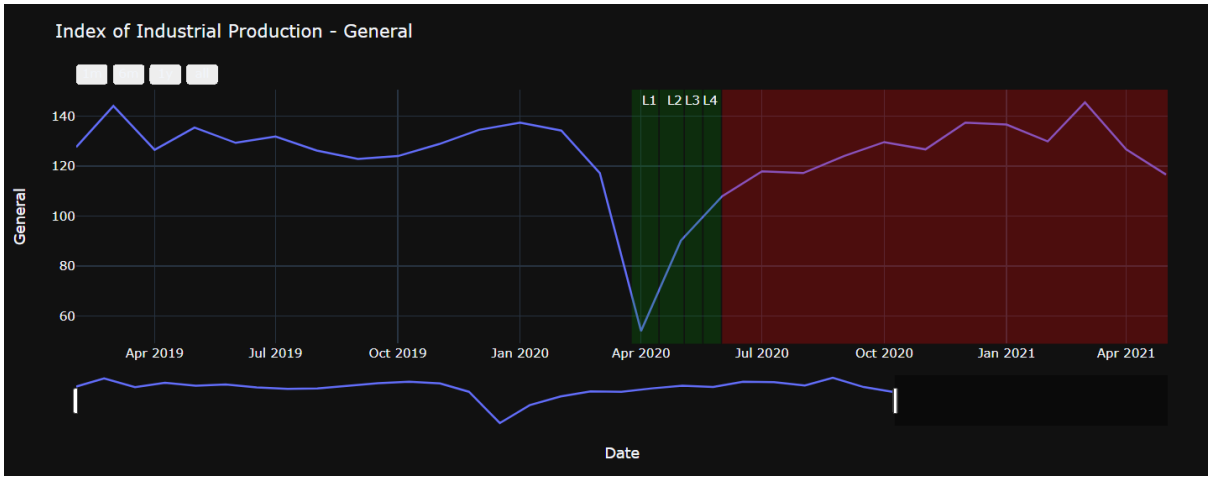
Household debt can be defined in several ways, based on what types of debt are included. Common debt types include home mortgages, home equity loans, auto loans, student loans, and credit cards. Household debt can also be measured across an economy, to measure how indebted households are relative to various measures of income (e.g., pre-tax and disposable income) or relative to the size of the economy (GDP).



By looking at the graph, it is apparent that there will be an increase but the forecasts are yet to done on my side

Index of Industrial Production

The Index of Industrial Production (IIP) is an index for India which details out the growth of various sectors in an economy such as mining, electricity and manufacturing.



The Index of Industrial Production (IIP) is an index which shows the growth rates in different industry groups of the economy in a stipulated period of time. The IIP index is computed and published by the Central Statistical Organisation (CSO) on a monthly basis.

Industrial Production declined sharply during lockdown but rose back steadily afterwards.

Impact on Water Quality

I took screenshots through GEE for this. That's why I won't call this a fair analysis because I just worked on data gathering here.

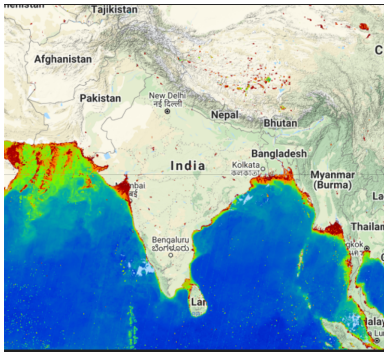
Chlorophyll

Chlorophyll a is a green pigment found in plants. It absorbs sunlight and converts it to sugar during photosynthesis. Chlorophyll a concentrations are an indicator of phytoplankton abundance and biomass in coastal and estuarine waters.

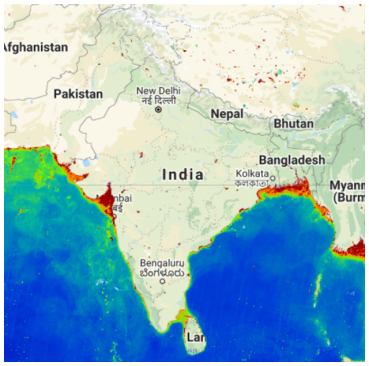
They can be an effective measure of trophic status1, are potential indicators of maximum photosynthetic rate (P-max) and are a commonly used measure of water quality.

High levels often indicate poor water quality and low levels often suggest good conditions.

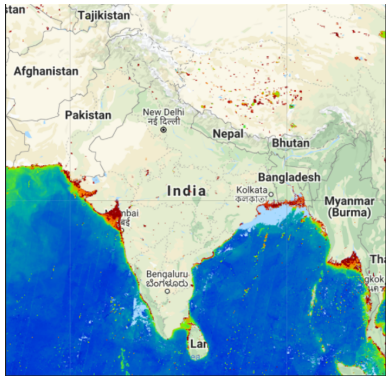
However, elevated chlorophyll a concentrations are not necessarily a bad thing. It is the long-term persistence of elevated levels that is a problem.



Chlorophyll 2019



Chlorophyll 2020



Chlorophyll 2021

Well, there isn't any special improvement too.

But we do less concentration of chlorophyll in some places in both 2020 and 2021.

Impact on Land Use - NDVI

Land Use is the term **used to describe the human use of land**. It represents the economic and cultural activities (e.g., agricultural, residential, industrial, mining, and recreational uses) that are practiced at a given place.

Usually, we take a look at the change of all the above properties with time.

The whole process goes something like this in QGIS atleast:

1. We take satellite data of a region and do some land cover classification
2. We check if the classification done is accurate
3. This classification is then done for the same place in next date
4. Then we do some change detection based on all the classifications through time probably through SCP

But I figured that there would be a lot of changes in the land cover and use with time intervals of 1 year. So here I took a shortcut and measured the NDVI levels of 4 different times.

What is NDVI?

Normalized Difference Vegetation Index (NDVI) quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs).

NDVI always ranges from -1 to +1. But there isn't a distinct boundary for **each type of land cover**

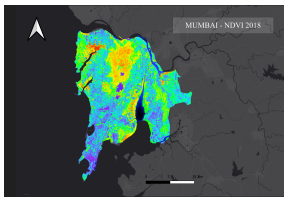
For example, when you have negative values, it's highly likely that it's water. On the other hand, if you have an NDVI value close to +1, there's a high possibility that it's dense green leaves. But when NDVI is close to zero, there aren't green leaves and it could even be an urbanized area.

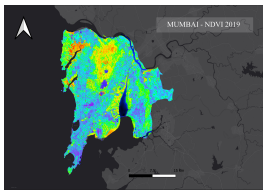
Mumbai in Consideration

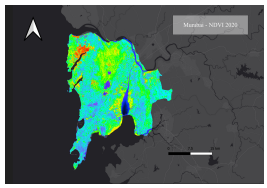
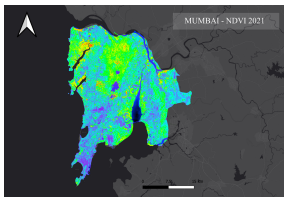
Here I took Landsat 8 data for the region of Mumbai. I looked at at the intensity of the NDVI through the years.

According to the color scale,

- The blue areas show the urbanized areas where there isn't any green.
- The green areas show light distribution of trees
- As the color goes from green to yellow or red, the density of green increases





Well we do see a decrease in the NDVI levels many areas.

Surprisingly, there is weird decrease in urban areas in 2020.

The problem with this approach is that it is not quantifiable.

This is an early analysis and will try to complete the proper change detection to verify in the future.

I could just do image subtraction for change detection but I doubt it will show good results.

Conclusion

The lockdown period did help in the improvement of the air quality of India but it did also bring in some socio-economic setbacks.

COVID-19 brought in a lot of problems and difficulties in life. Some people benefitted from this situation, but a vast majority saw the dark sides of life.

But one thing is common in my analysis, that we bounce back from this trauma and live life again.

Climate risk is real and COVID-19 is just a consequence of climate change. This COVID-19 period has given a us a gift - it has given us a chance! To bounce back but sustainably.

How did your solution involve geospatial data?

- I used geospatial data for monitoring the environmental factors of the project like air quality, water chlorophyll level and for monitoring land use using NDVI

Does you solution require improvements in terms of data or methodology?

Yes, in many ways.

- It was my choice to choose India as my subject and I did know that India as of now has less historical data.
    - But there are good sites like opendata from the Indian government that help
    - But I think that it would be better to get updated data
- I faced some problems with NetCDF files
    - Because I wanted to use QGIS only and not SNAP or Panoply, it made things a little difficult for me to visualize things
    - I will learn these platforms in the future.
- It would probably be better to use GEE instead of QGIS here
    - Because, GEE is quite a good platform in terms of speed and versatility because of its cloud infrastructure and coding interface.
    - I will probably try to use GEE in QGIS next time
- It would probably be much better to emphasis the impact if I had forecasted the quantities as if there was any disease called COVID-19
    - I could try to forecast the values of 2020-21 as a normal situation if I had only considered data before the pandemic
    - I will try that in the future
- It would be much better if I had done some land cover classification
    - That way, I could quantify the changes and it would help uncover more details
    - I will also do that in the future

As of now, these are some things I could improve on. But I would like to wait for the expert opinion.