Environmental Impacts of COVID-19

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What? In response to the COVID-19 pandemic which intensified around March 2020, several countries enforced preventive measures, most commonly the nationwide lockdowns. While this significantly impacted social and economic activities, it gave nature a chance to demonstrate a short-term healing, which further emphasized the need to address climate change, primarily driven by anthropogenic activities. One of the major effects observed was the decline in levels of air pollution. The main cause for this can be attributed to the severe restrictions imposed on various modes of transportation along with reduced industrial activities. In this study, the variations in NO_2 are considered to understand some environmental effects of COVID-19.

Why? NO_2 is one of the major air pollutants which causes adverse health effects and also produces secondary pollutants such as ozone. The major sources of NO_2 emissions include combustion of fossil fuels in road transport, aviation, shipping, industries, and thermal power plants. Hence strong correlation can be observed between the decline in NO_2 levels during lockdown and reduced anthropogenic activities like road transport.

Where? Decline in NO_2 levels can be observed majorly over urban regions. I have considered various urban areas including Los Angeles in US and Delhi in India to demonstrate the correlation.

How? For this study, I have used Google Earth Engine (GEE), Jupyter Notebook and open datasets. Figure 1 shows the methodology used in this study.
Python packages used : ee, geemap, plotly, pandas, numpy

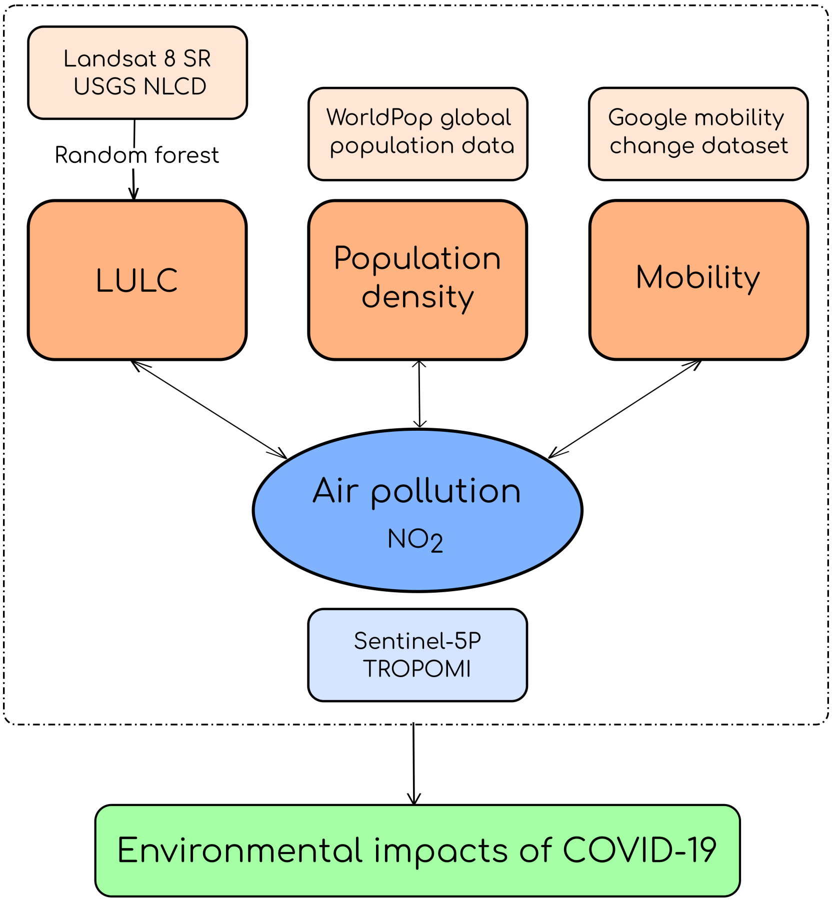
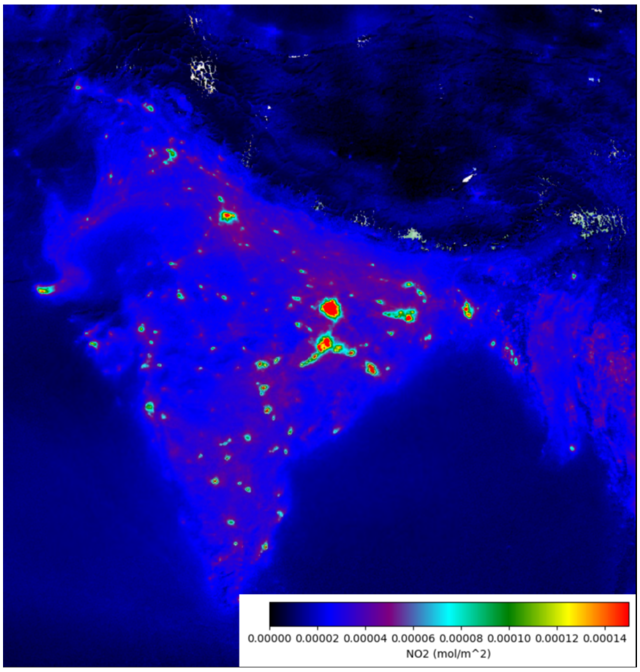


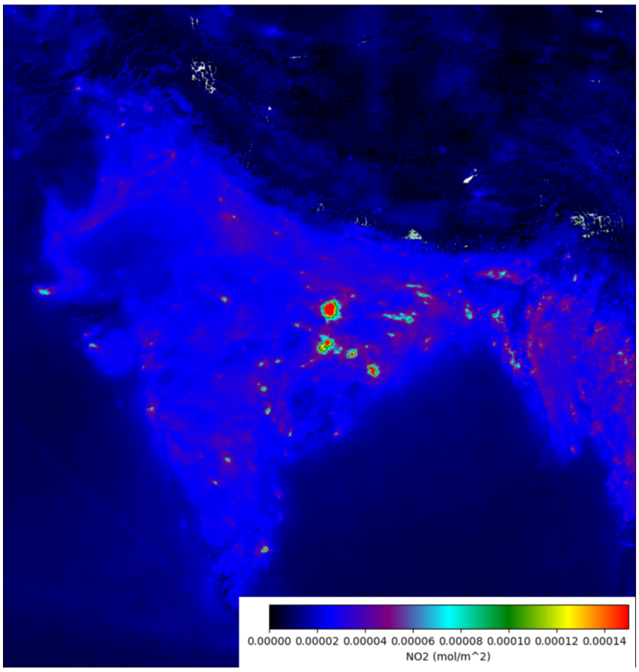
Figure 1: Methodology of this study along with sources of data used

1 Changes in NO_2 during lockdown

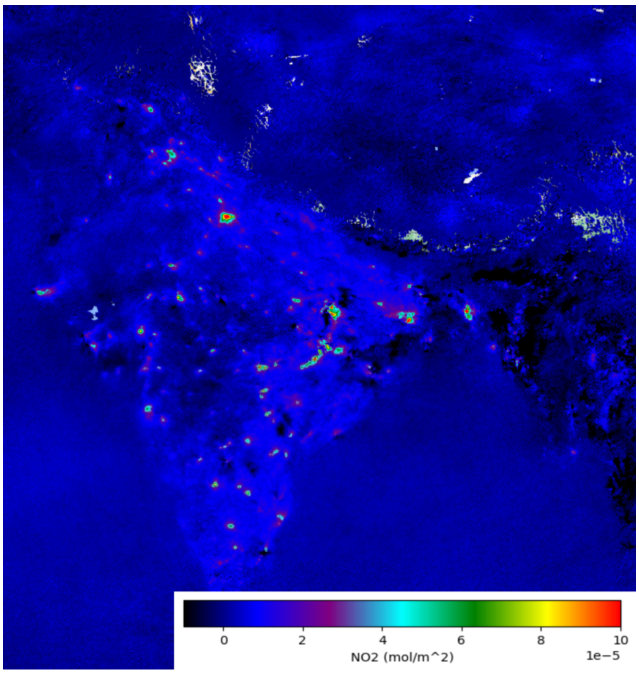
- **Aim**: Obtain NO_2 change map over India.
- **Data**: Sentinel-5P OFFL NO2: Offline Nitrogen Dioxide (GEE catalog).
- **Assumption**: Weather variability did not have much impact on NO2 levels over India and most of the changes were driven by a change in the anthropogenic emissions (Biswal et al., 2021).
- The first lockdown in India spanned from 25 March 2020 to 03 May 2020. The corresponding period in 2019 is used as a reference for NO_2 emissions in a business-as-usual (BAU) scenario.
- Change in NO_2 = $NO_{2_{2019}}$ - $NO_{2_{2020}}$



(a) 2019



(b) 2020



(c) Change in NO_2

Figure 2: Average tropospheric NO_2 column density for the period 25 March to 03 May.

2 LULC and change in NO2

- **Aim**: Obtain reduction in NO_2 due to lockdown over different land cover categories.
- **Data**: LandSat 8 surface reflectance and USGS National Land Cover Database (GEE catalog).
- **Assumption**: Landcover has not varied significantly over the period corresponding to lockdown in each year.
- **Study area**: Los Angeles (LA).

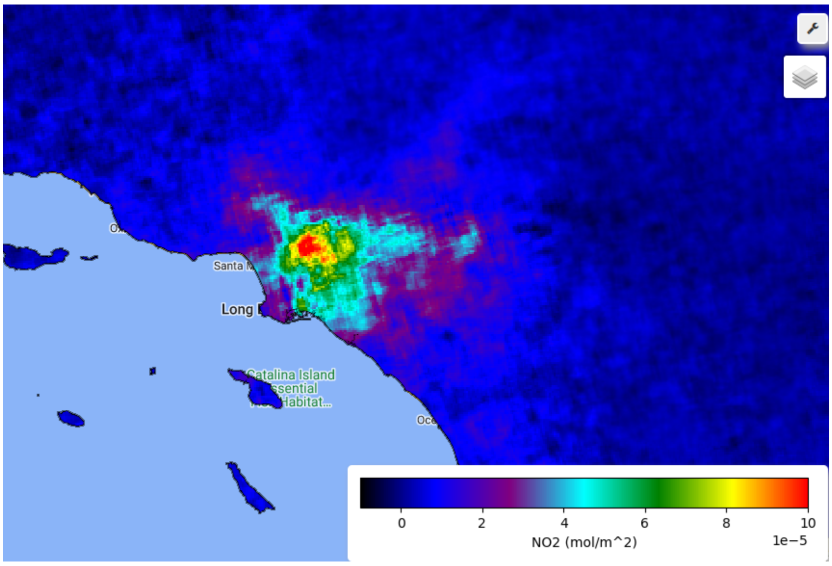
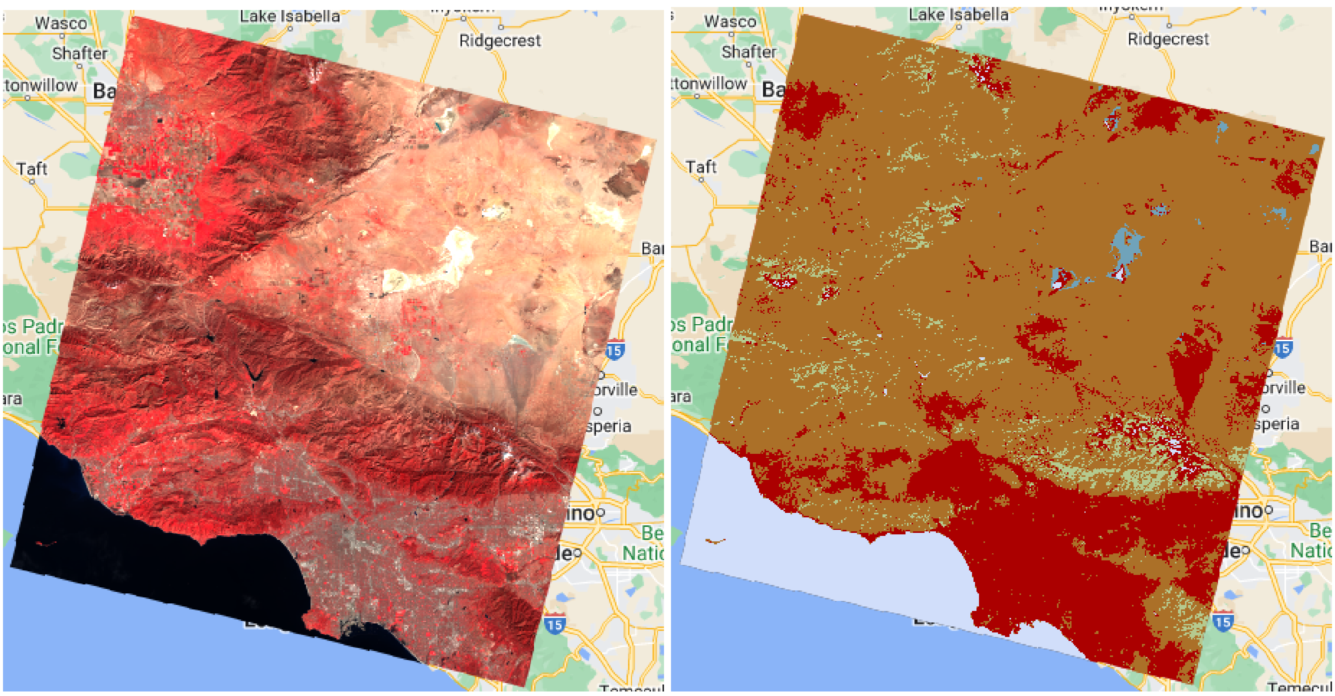


Figure 3: High reduction in NO_2 observed over LA.

- In order to obtain representative landcover categories for 2019 and 2020 corresponding to the lockdown period, a **Random Forest** classifier was applied on Landsat 8 surface reflectance image with least cloud cover during the given period. NLCD data was used as a proxy for ground truth labels. NLCD classes were regrouped into 5 classes : Water, Urban, Forest, Vegetation, Other.
- 80-20 split was used for training and validation. Model **accuracy** of 87% was obtained for the classification.



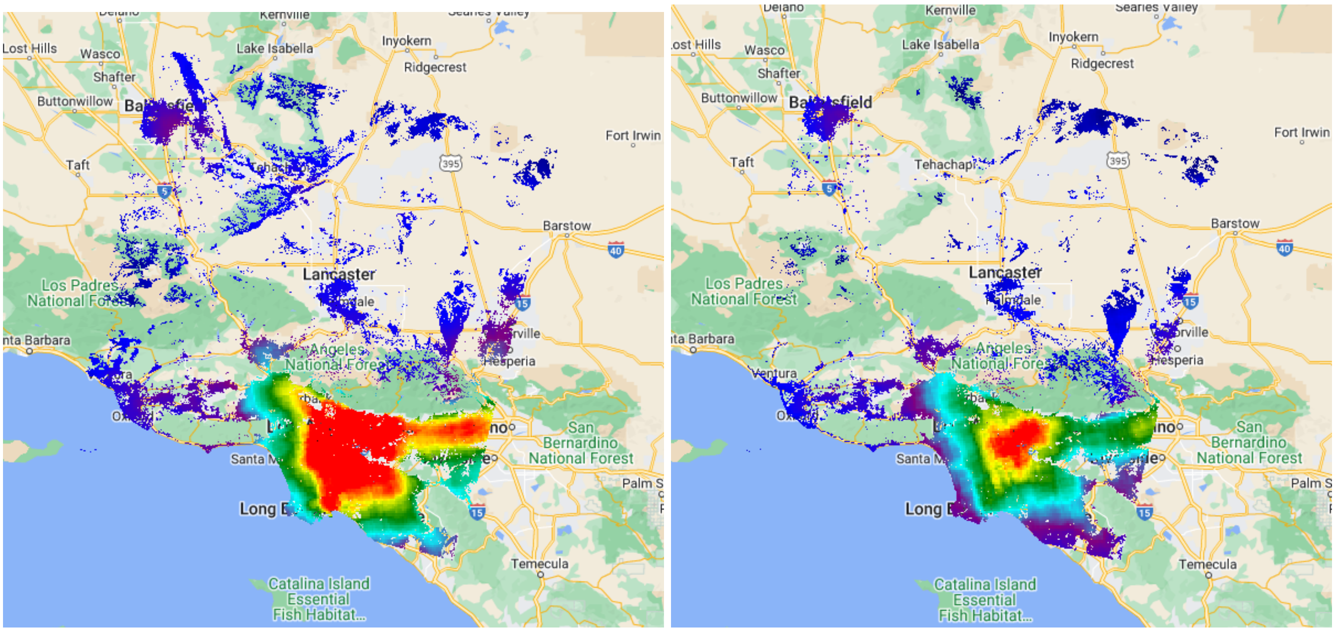
(a) FCC of Landsat 8 image

(b) Land cover map obtained after classification

Figure 4

- Class masks for Urban, forest and vegetation were obtained for both 2019 and 2020. Classwise emissions were obtained as follows:

$$\text{Reduction in } NO_2 \text{ over urban} = NO_2 \text{ over urban in 2020} - NO_2 \text{ over urban in 2019}$$



(a) Urban pixels in 2019 (b) Urban pixels in 2020

Figure 5

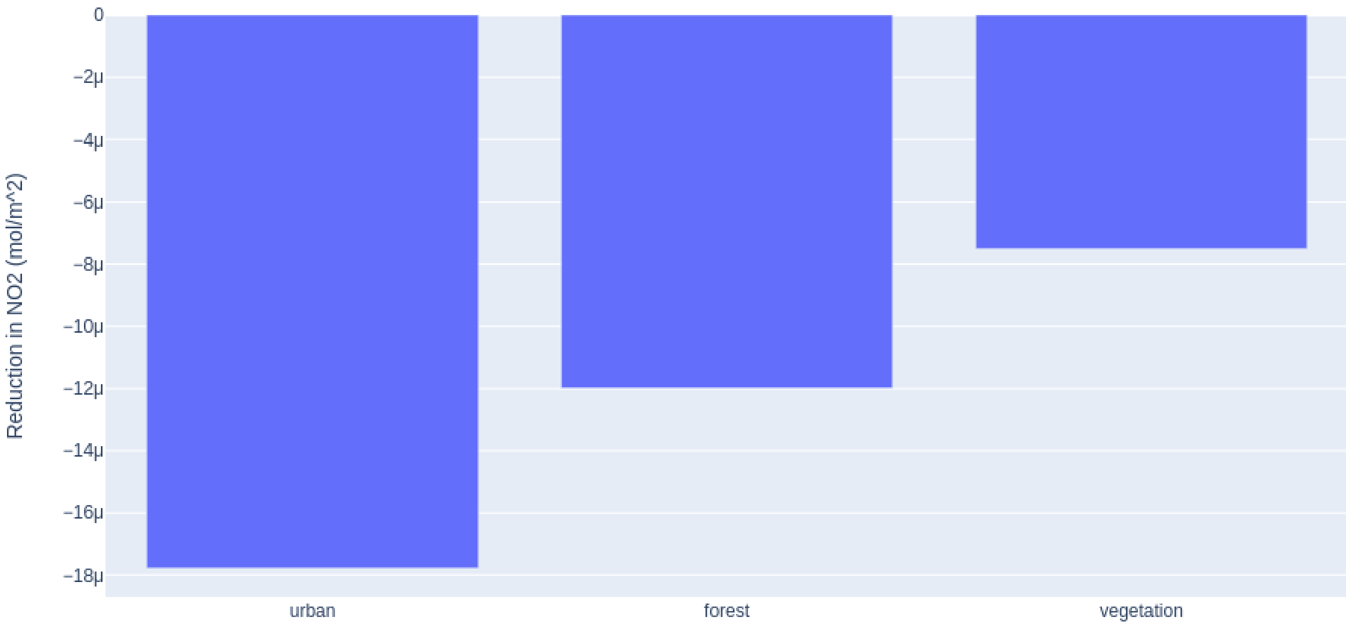


Figure 6: Classwise reduction in NO_2 in 2020 in comparison to 2019.

- **Conclusion**: Maximum reduction in NO_2 is observed over the urban class.

3 Population density and change in NO_2

- **Aim**: Obtain correlation between change in NO_2 and population density over various Indian states.
- **Data**: WorldPop global population data (GEE catalog).
- **Study Area**: Indian states.
- Resolution of WorldPop data was reduced by averaging to match the resolution of the NO_2 data.

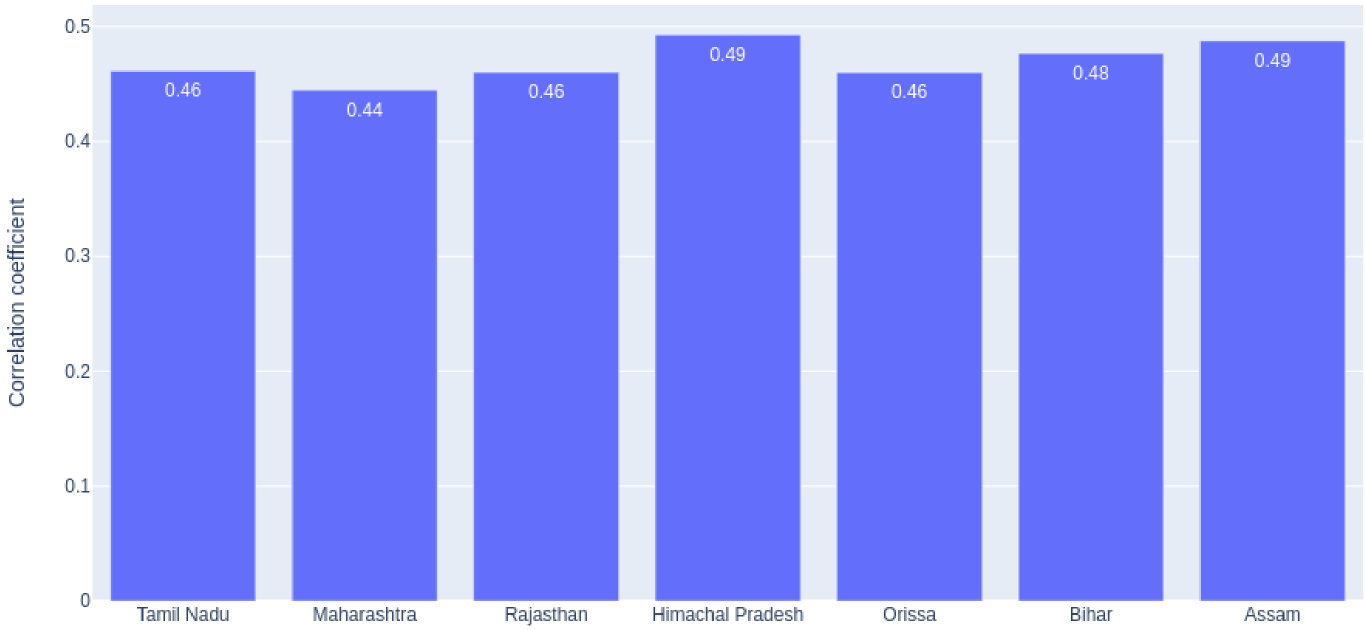
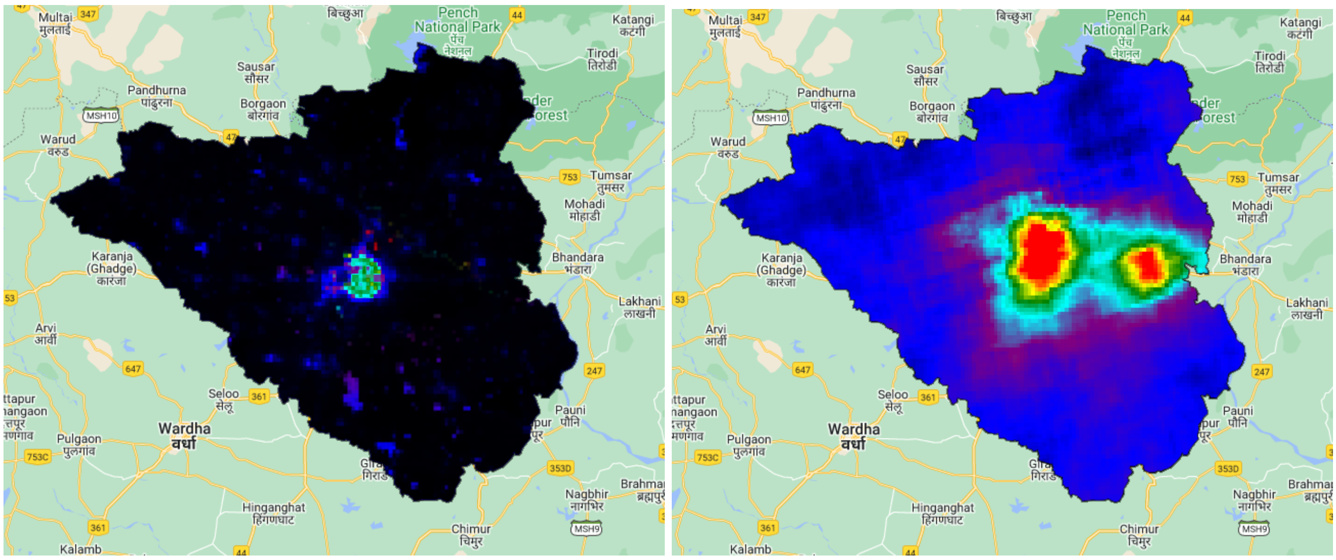


Figure 7: Correlation between population density and change in NO_2

- **Conclusion**: Positive correlation is observed between change in NO_2 and population density. This suggests an increase in the reduction of NO_2 with an increase in the population density, which generally occurs in urban areas.
- The low positive value is due to the fact that other factors such as fire anomalies or large thermal power plants also contribute significantly to NO_2 emissions.



(a) Population density around Nagpur

(b) Change in NO_2 around Nagpur

Figure 8

- The high change in NO_2 emissions near Nagpur is due to the presence of Mauda Super Thermal Power Station in the region.

4 Mobility and change in NO_2

- **Aim**: Obtain correlation between change in NO_2 and deviation in mobility from baseline.
- **Data**: Google mobility change dataset
- **Assumption**: Mobility in transit stations is a proxy for road transport.
- **Study Area**: Delhi

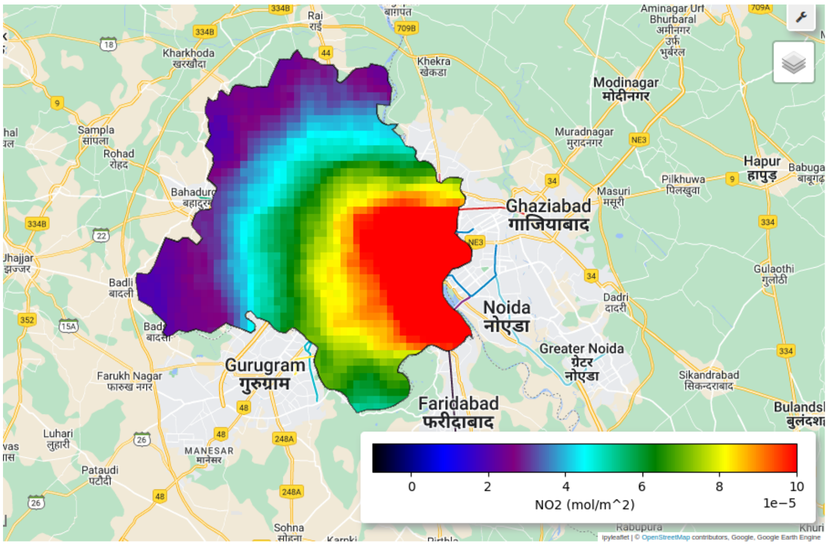


Figure 9: Change in NO_2 over Delhi due to lockdown.

- Delhi has high population density and consequently high emissions resulting from urban transport. Due to the severe restrictions imposed on transportation, a decline is seen in mobility during the lockdown period.

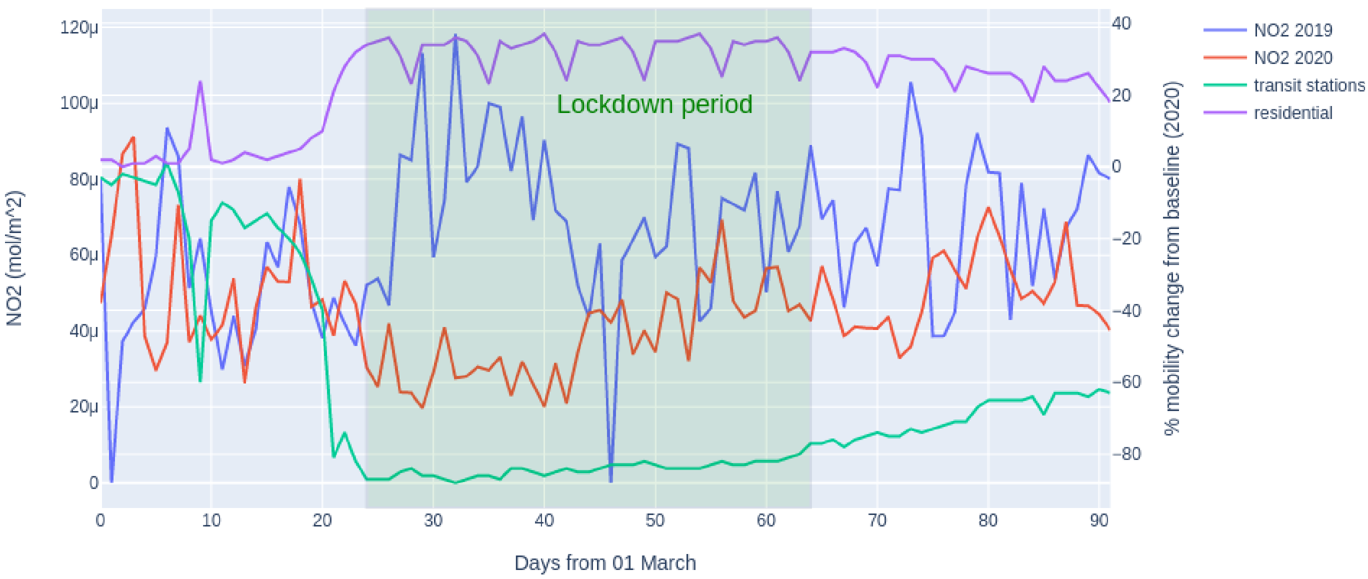


Figure 10: Trends of NO_2 emissions and mobility changes.

- Pearson correlation co-efficient for change in mobility and change in NO_2 = 0.42.
- **Conclusion**: The positive correlation suggests that the reduction in NO_2 is linked to reduced traffic emissions due to COVID-19 restrictions.

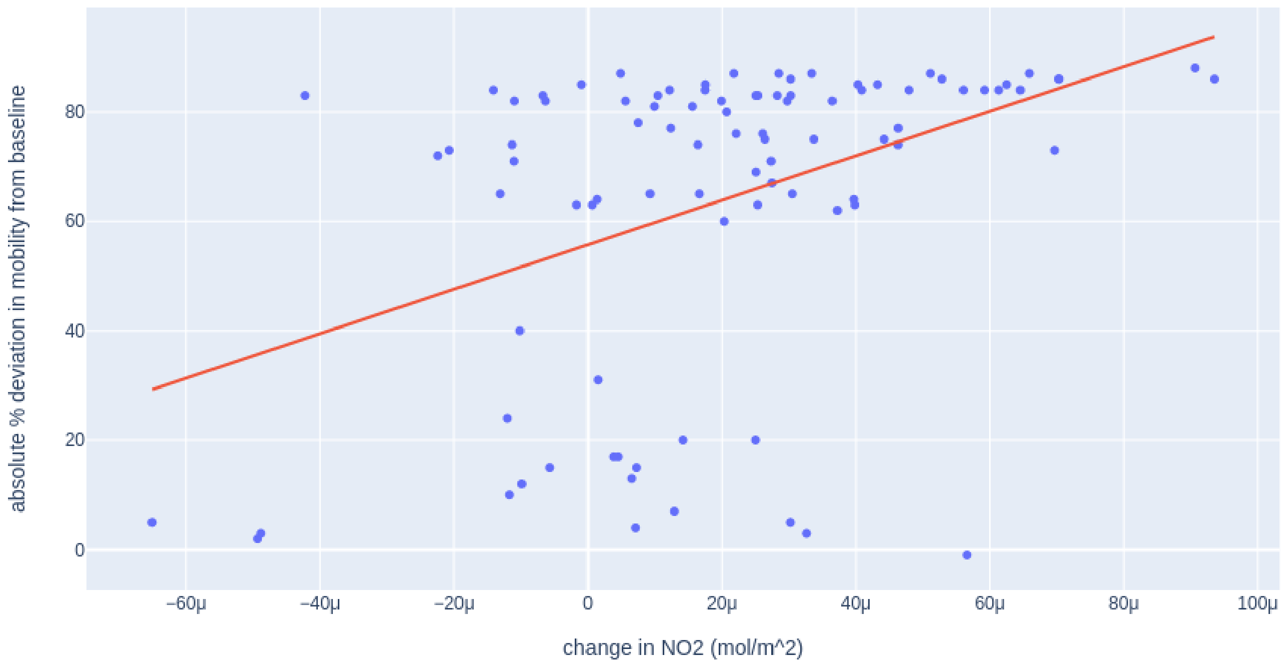


Figure 11: Correlation between change in NO_2 over Delhi due to lockdown and mobility change in transit stations.

5 Summary

- Significant reduction in NO_2 levels were observed during the COVID-19 lockdown compared to the same period during 2019.
- **Key takeaways**: Largest reduction was seen in the urban areas and positive correlation was obtained between change in NO_2 and anthropogenic attributes like population density and mobility.
- Suggested improvements to the study: Include other contributing factors such as thermal power plants, fire emissions, meteorological factors etc. along with in-situ observations of pollutants.
- The clear connection between anthropogenic factors and air pollution stresses the need for policies and management strategies aimed at reducing emissions which can help in the fight against climate change.

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