Monitoring the Impact of COVID-19 Lockdown and Correlates on Nigeria's Air Quality Using TROPOMI Data

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Abstract

Abstract It has been debated globally that the COVID-19 lockdown had significantly diminished the emission levels of anthropogenic greenhouse gases (GHGs). However, different countries possess different footprints of GHGs emission. In regions with inconsistent air quality observation, spaceborne sensors can provide synoptic assessment of air quality with time-based environmental decision making. In this study, we utilised satellite data to quantify the temporal dynamics of carbon monoxide (CO) and nitrogen dioxide (NO_2) between the pre-lockdown (January–March 2020), lockdown (April–July 2020) and post-lockdown (August–September 2020) periods in Nigeria. Periodic TROPOspheric Monitoring Instrument (TROPOMI) datasets were acquired from the Google Earth Engine Sentinel-5 Explorer and the Copernicus Open Access Hub. The Population-Weighted Mean Concentration (PWEC) of CO and NO_2 was computed using raster-based population data and place-based air quality estimates. The associated economic correlates were computed using data mined from TROPOMI and available health records of Nigeria. Satellite data analysis showed that aggregate CO reduced by 35.1% (25.32[?]10^5 tons) and 9.06% (6.54[?]10^5 tons) and NO_2 plummeted by 32.81% (22,500 tons) and 11.63% (5,360 tons) during the lockdown and post-lockdown periods across the 36 States of the country. While mobility rate dwindled substantially, mortality rate savings from the exposure to damaging effects of the GHGs were roughly \$ 14 million (CO) and \$10 million (NO_2). The fluxes in CO and NO_2 suggest that anthropogenic interference in air quality accounting can aid the understanding of the convoluted human–nature relationships for sustainable environmental management.

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I. Introduction

With the event of the COVID-19 lockdown and its antecedent impact on global air quality, the measurement of the emission levels of anthropogenic greenhouse gases (GHGs) becomes more inevitable, in part, owing to its nexus with public health and safety (Sicard et al., 2020). While developed countries have overtime developed a network of state-of-the-art approaches for monitoring of air quality, developing countries have often grappled with piecemeal systems which oftentimes are inconsistent particularly when sudden events such as the COVID-19 pandemic surfaces (Sannigrahi et al., 2021). Using Nigeria as a case study, this study relies on data from spaceborne sensor to spatiotemporally monitor the impact of mobility restrictions on air quality. It further probes the possible economic benefits of the lockdowns on public health burden which is essential for environmental decision making particularly health and safety.

II. Objectives

- To assess the spatiotemporal dynamics of two air quality parameters - carbon monoxide (CO) and nitrogen dioxide (NO_2) in Nigeria across the pre-lockdown, lockdown, and post-lockdown periods.
- To analyse the pattern of mobility changes in Nigeria within the COVID-19 lockdown period.
- To ascertain the nexus between reduced anthropogenic emission of CO and NO_2, and economic benefits and correlates of public health burden in Nigeria.

III. Methods

- Three data periods were designed for this study: the pre-lockdown period (January to March 2020), the lockdown period (April to July 2020); and the post-lockdown period (August to September 2020). These periods were tracked to Google COVID-19 Mobility datasets.
- Periodic data from the TROPOspheric Monitoring Instrument (TROPOMI) were acquired via the Google Earth Engine Sentinel-5 Explorer and the Copernicus Open Access Hub.
- The Population-Weighted Average Concentration (PWAC) of CO and NO_2 was computed with population data and air quality estimates to further compute public health burden and available health records of Nigeria.
- The overall study procedure is presented in Fig. 1.

Additional data sources

- The Google COVID-19 Mobility Data for Nigeria was sourced from the portal https://www.google.com/covid19/mobility/ (country and state-wide levels).
- Population density data (pixel) were sourced from SEDAC (Socio-Economic Data Application Center) of NASA.
- Data on mortality risk of air pollutant was acquired from cardiovascular and chronic respiratory rate of the Global Burden of Disease study (2017).
- The current price conversion factors for the two pollutants were estimated as $956 and $5,149 per ton for CO and NO_2 respectively from NBS.

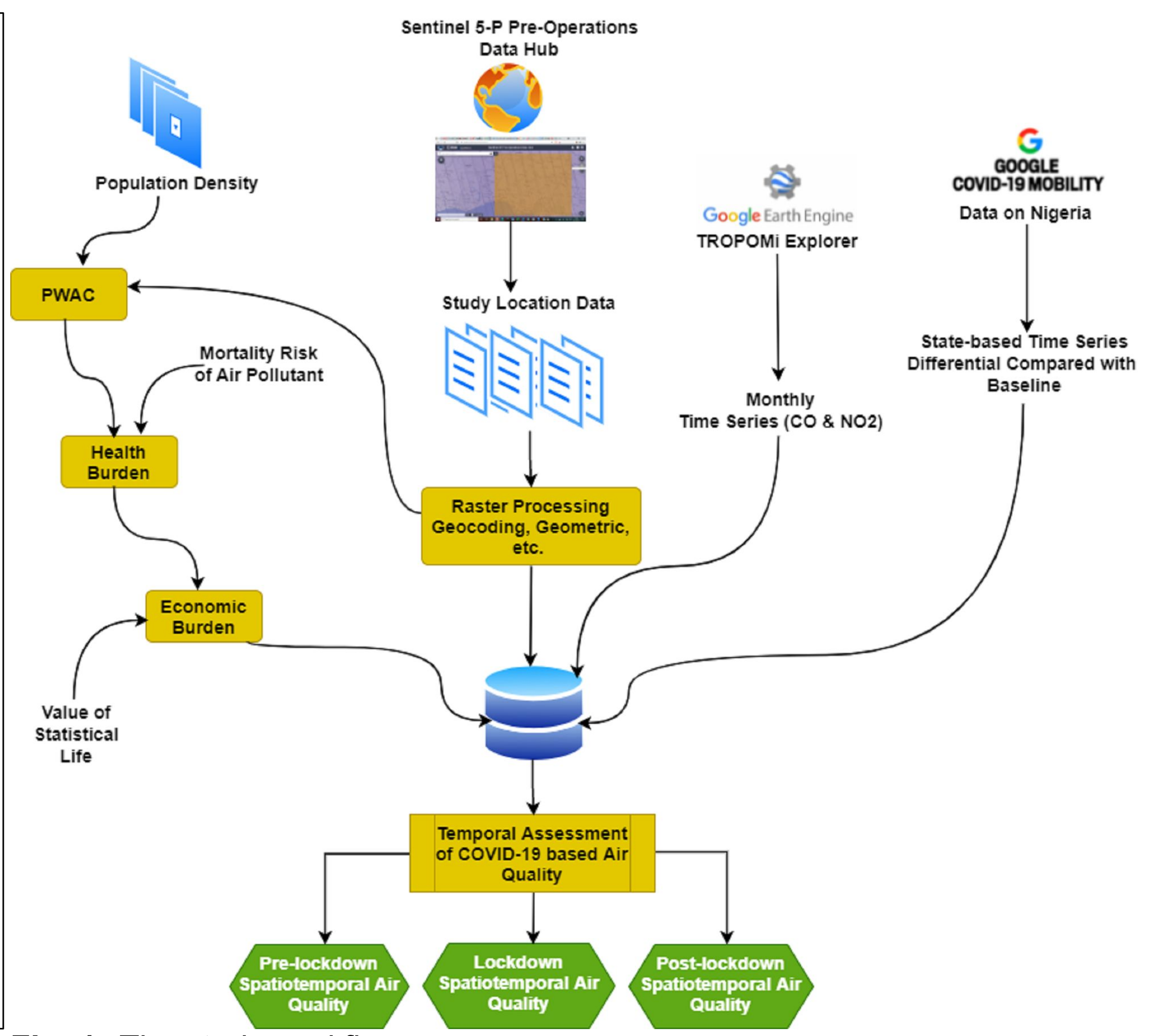
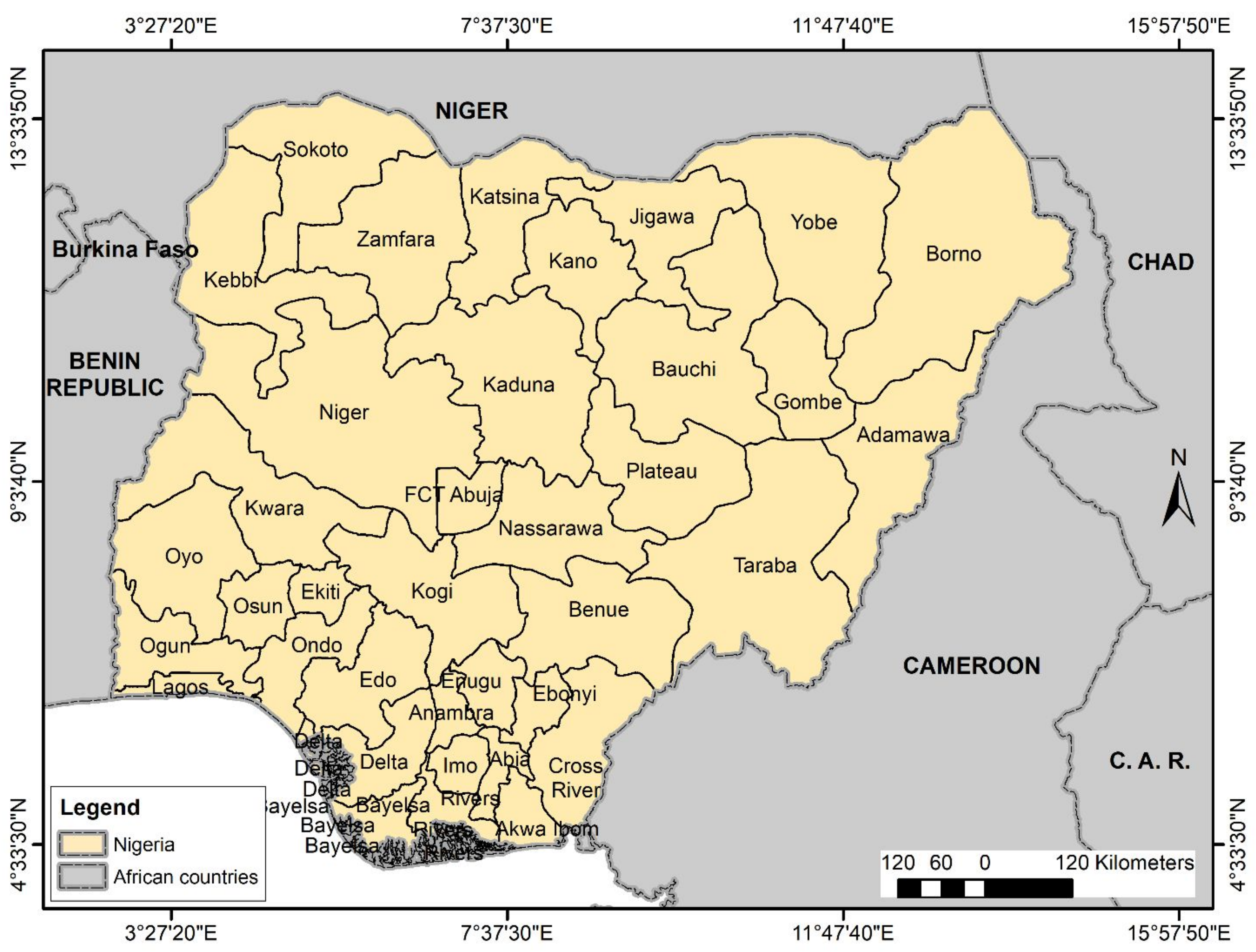


Fig. 1: *The study workflow*

IV. Study Location

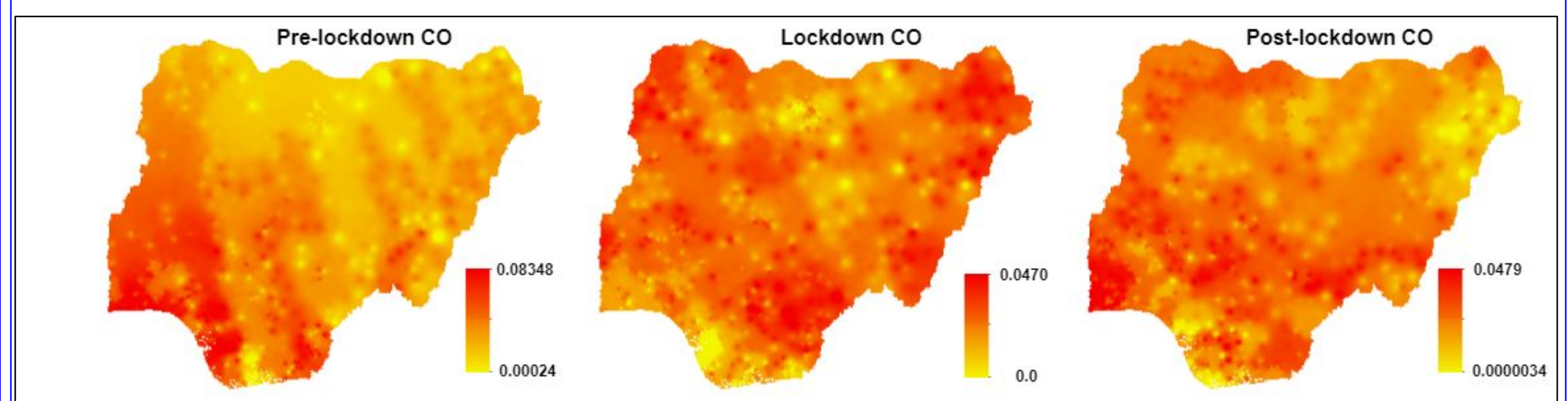


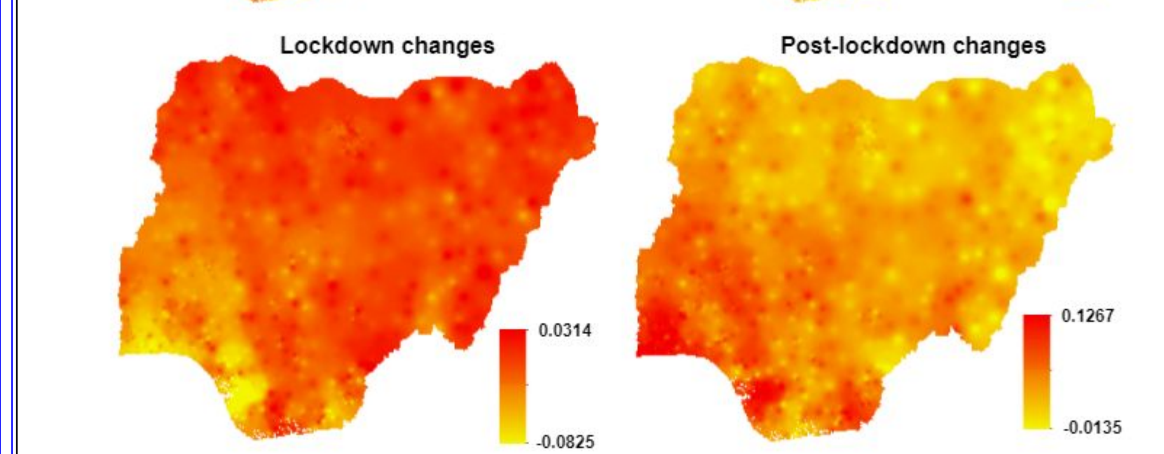
Context

- 36 administrative regions (States) with FCT Abuja.
- 10 industrial areas (NEPZA): Lagos, Ogun, Rivers, Anambra, Kano, Abia, Akwa Ibom, Imo and Osun.
- Location of oil & gas activities: Rivers, Delta, Bayelsa, Lagos, Akwa Ibom, Imo, Kaduna,
- High road traffic intensity areas: Lagos, Ogun, Oyo, Kaduna, Edo, FCT Abuja, Kano, and Kaduna.
- Agrarian divide: north-south.

Fig. 2: *The study area in adjoining West Africa countries in context of associated human activities*

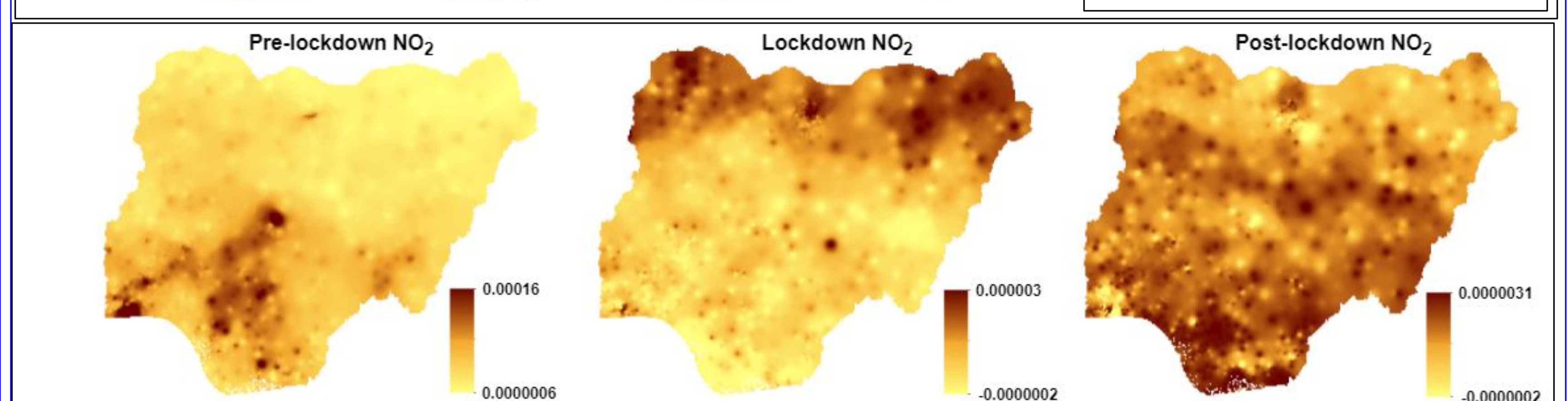
V. Spatiotemporal dynamics of CO and NO2 within the study periods

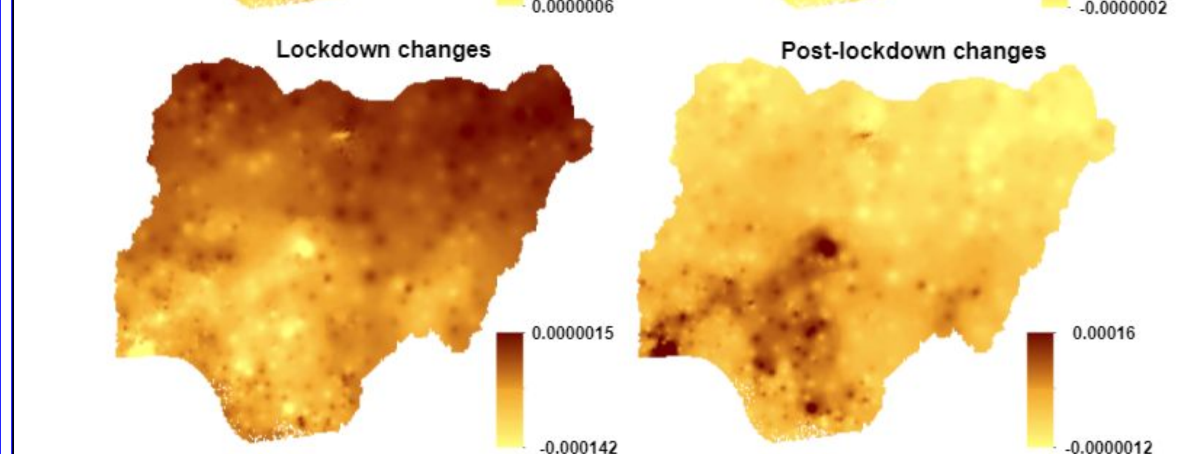




Observations and notes

- Measurements in mol/m^2.
- Lockdown changes show a progressive shift hinterland from the coast with with a range of -43.7% to 24.44% compared to baseline.
- Post-lockdown changes depicts a quasi-return to baseline with percentage range of -3.4*10^4 to 1.91.
- Most changes were observed in Lagos, Bayelsa, Oyo, Cross River, Edo, and Ogun.

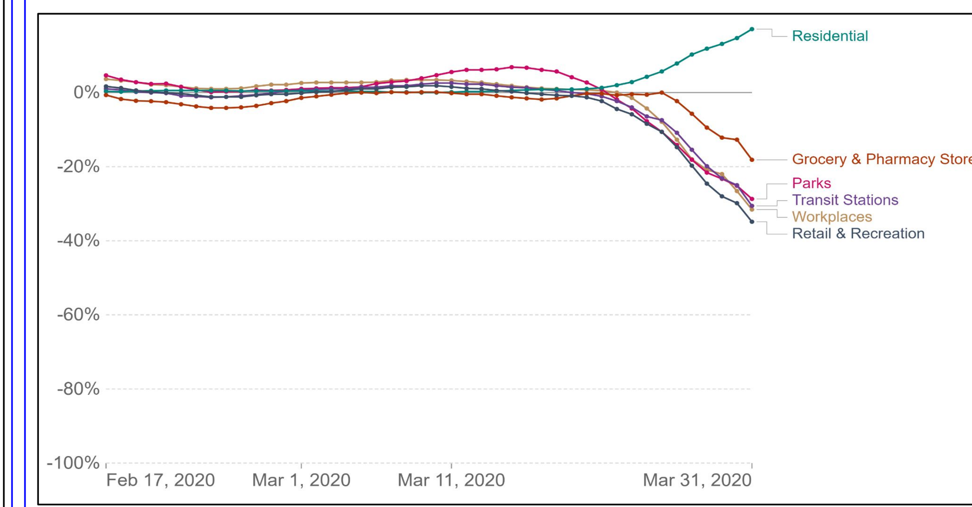




Observations and notes

- Measurements in μmol/m^2.
- Lockdown changes show a northward shift compared to the southward baseline concentration with a range of -103.33% to 98.13%.
- Post-lockdown changes depicts a quasi-return to baseline with percentage range of -100.11 to 33.33.
- Most changes were observed in Lagos, Cross River, Kano and Ogun.

VI. Dynamics of human mobility within the study periods

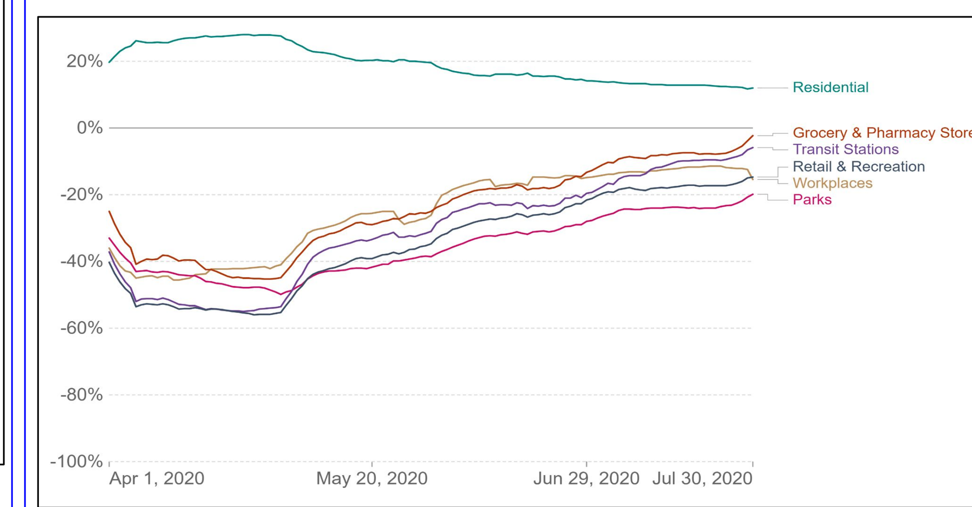


Observed changes compared to baseline*

1. **Retail and recreation** including restaurants, cafés, shopping centres, museums and cinemas: reduced by 3.97%.
2. **Supermarket and pharmacy**: including groceries, foodstores, farmers markets, food shops and pharmacies: reduced by 2.54%.
3. **Residential** covering forms of residences: increased by 2.40%.
4. **Transit stations** includes public transport hubs, bus and train stations: reduced by 2.77%.
5. **Parks** including public beaches, marinas, plazas and public gardens: reduced by 1.23%.
6. **Workplaces** including places of employment for private and civil services: reduced by 1.61%.

Fig. 3: *Mobility trends during the pre-lockdown period in Nigeria*

****The baseline is the median value, for the corresponding day of the week, during the five-week period 3 Jan – 6 Feb 2020.***

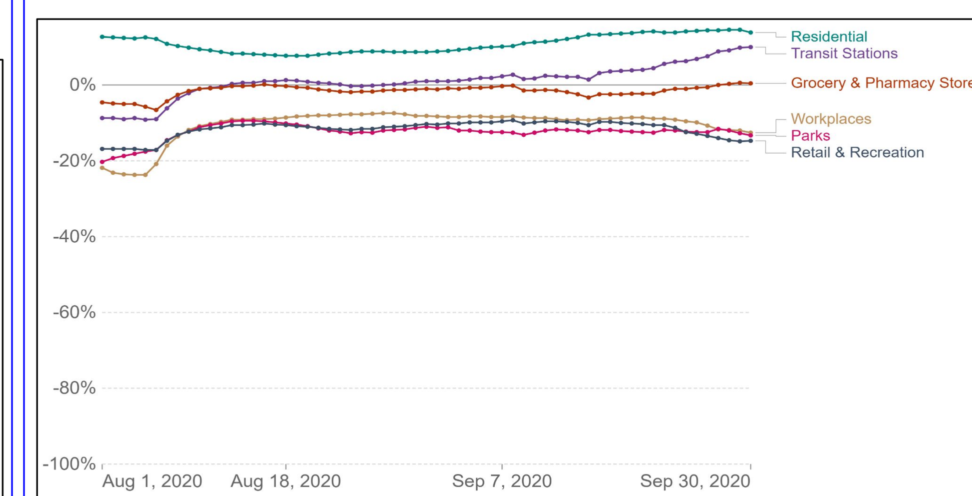


Observed changes compared to baseline*

1. **Retail and recreation** including restaurants, cafés, shopping centres, museums and cinemas: reduced by 34.77%.
2. **Supermarket and pharmacy**: including groceries, foodstores, farmers markets, food shops and pharmacies: reduced by 24.4%.
3. **Residential** covering forms of residences: reduced by 19.25%.
4. **Transit stations** includes public transport hubs, bus and train stations: reduced by 35.67%.
5. **Parks** including public beaches, marinas, plazas and public gardens: reduced by 35.67%.
6. **Workplaces** including places of employment for private and civil services: reduced by 25.52%.

Fig. 4: *Mobility trends during the lockdown period in Nigeria*

****The baseline is the median value, for the corresponding day of the week, during the five-week period 3 Jan – 6 Feb 2020.***



Observed changes compared to baseline*

1. **Retail and recreation** including restaurants, cafés, shopping centres, museums and cinemas: reduced by 11.67%.
2. **Supermarket and pharmacy**: including groceries, foodstores, farmers markets, food shops and pharmacies: reduced by 1.59%.
3. **Residential** covering forms of residences: increased by 10.85%.
4. **Transit stations** includes public transport hubs, bus and train stations: increased by 1.02%.
5. **Parks** including public beaches, marinas, plazas and public gardens: reduced by 12.45%.
6. **Workplaces** including places of employment for private and civil services: reduced by 10.55%.

Fig. 5: *Mobility trends during the post-lockdown period in Nigeria*

****The baseline is the median value, for the corresponding day of the week, during the five-week period 3 Jan – 6 Feb 2020.***

VII. Health burden: Abated anthropogenic emission & human mobility

- A range of -35% to 62% population-weighted average concentration was computed across the study periods indicating a major change in the exposure level to CO and NO_2.
- A north-south increasing spatial differentiation index was observed in Nigeria indicating a higher health burden in the south compared to the north.
- Overall, public health savings rounded up to $ 14.31 million and $10.42 million for CO and NO_2 respectively within the periods of study.
- Consequently, reduced anthropogenic emissions, coupled with managed mobility can significantly contribute to the improvement of air quality status of different locations.

VIII. Conclusions and Future Research Directions

- This research demonstrates the strong nexus between the decline in human mobility and reduction of CO and NO_2 across Nigeria.
- While substantial economic benefits were derived from public health concerns, the spatial distribution of these across the various subnational (state) levels of Nigeria will need to be investigated for concomitant health assessments and facility provisions.

References

Sicard, P., De Marco, A., Agathokleous, E., Feng, Z., Xu, X., Paoletti, E., Rodriguez, J.J.D., Calatayud, V., (2020). Amplified ozone pollution in cities during the COVID-19 lockdown. Sci. Total Environ. 735. https://doi.org/10.1016/j.citotenv.2020.139542.

Srikanta Sannigrahi, S., Kumar, P., Molter, A., Zhang, Q., Basu, B., Basu, A. S., Pilla, F., (2021). Examining the status of improved air quality in world cities due to COVID-19 led temporary reduction in anthropogenic emissions. Environ. Res. 196: 110921. https://doi.org/10.1016/j.envres.2021.110927.

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