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Spatio-Temporal Assessment of NO_2 Pollution in Bangladesh

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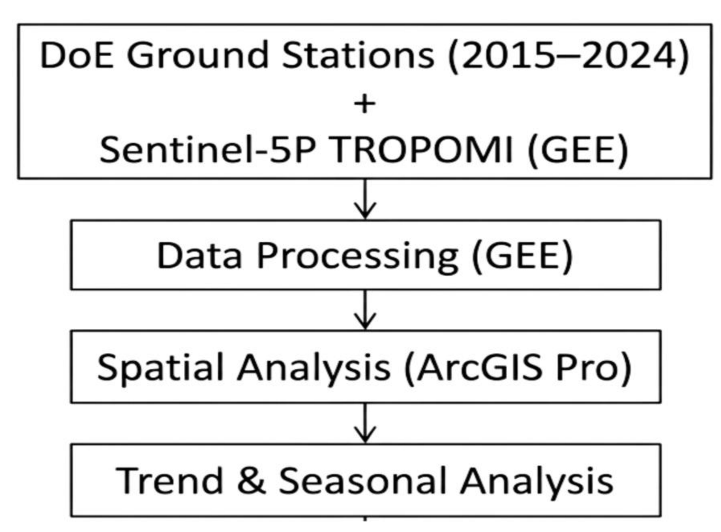
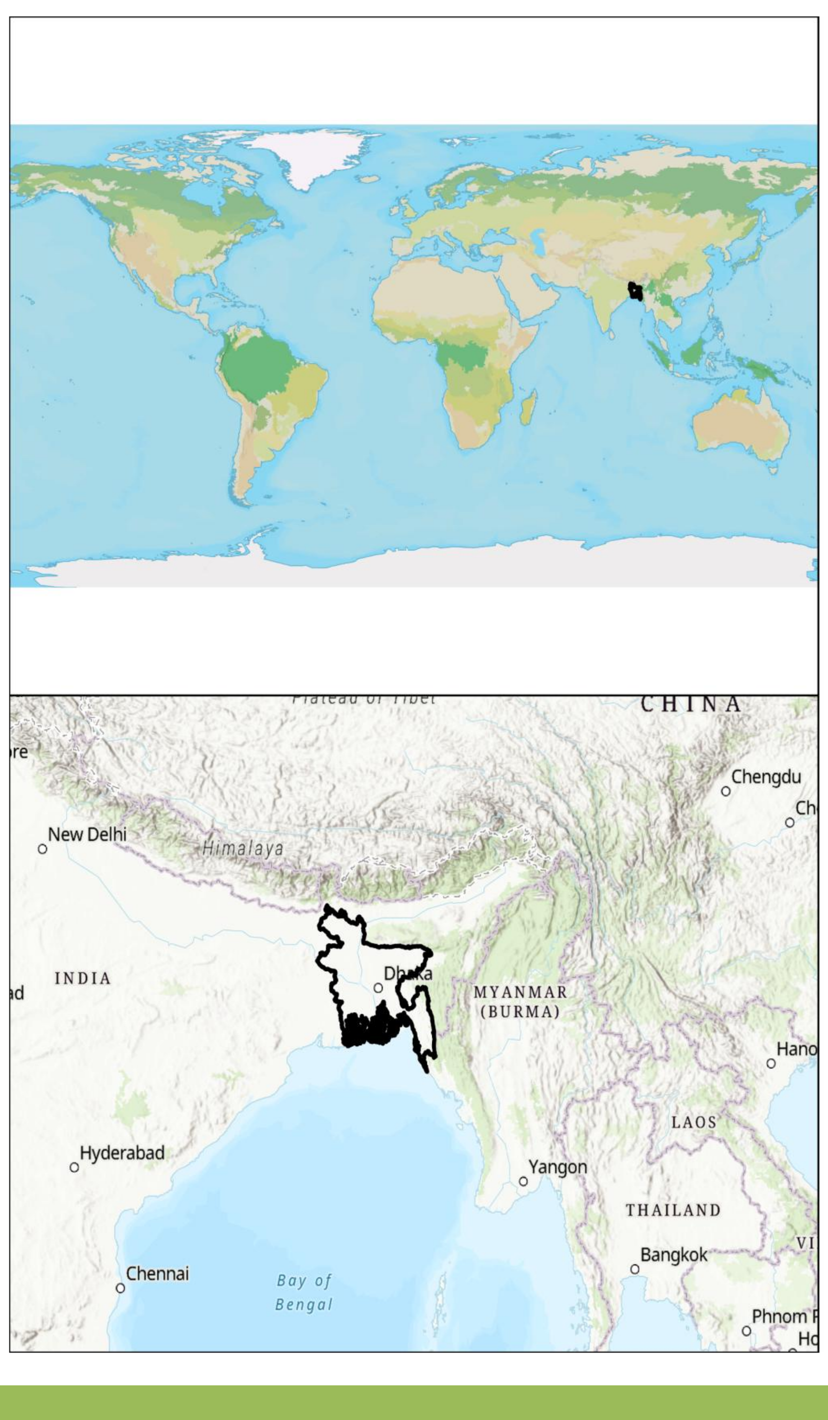
ABSTRACT

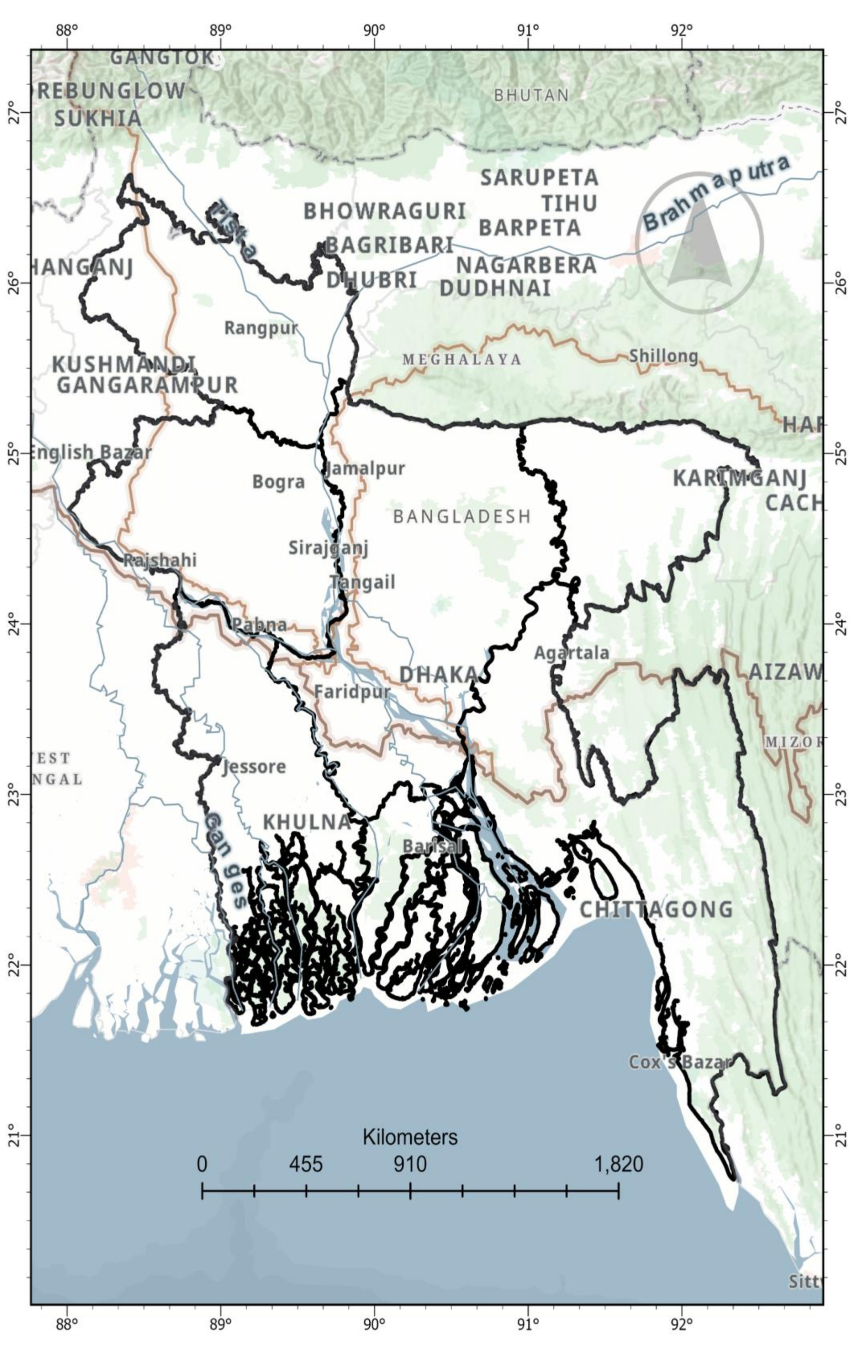
Anthropogenic air pollution represents a significant threat to both environmental and human health, with nitrogen oxides (NOx) playing a substantial role in the formation of photochemical smog, acid rain, eutrophication, and respiratory diseases. In Bangladesh, NOx emissions primarily originate from combustion sources such as road transportation, power generation, and industrial activities, while natural sources include lightning, wildfires, and soil emissions. Furthermore, ammonia emissions from fertilizers and livestock exacerbate air quality issues in both urban and rural settings. Despite the acknowledgment of vehicular and industrial contributions, comprehensive and systematic assessments of NO_2 trends across the nation remain scarce. This study integrates ground-based NO_2 measurements from the Department of Environment (DoE) with atmospheric NO_2 retrieved from the Sentinel-5P TROPOMI Level-3 product via Google Earth Engine (GEE) for 2024. Spatial distribution patterns of both ground-level and atmospheric NO_2 were analyzed using ArcGIS Pro, along with seasonal and decadal trend assessments from 2015 to 2024. Results indicated pronounced spatial and temporal variability in NO_2 concentrations. The highest levels were consistently recorded over Dhaka and surrounding industrial zones, with moderate accumulation in Chattogram. Winter months (December–February) exhibited hazardous concentrations, including a peak of 212 µg/m³ in Sylhet in 2016, while monsoon periods recorded the lowest levels, such as 0.46 µg/m³ in Khulna in May 2017. Seasonal averages indicated the highest concentrations in autumn (35.13 µg/m³), followed by winter (25.67 µg/m³), with November recording the maximum monthly mean (38.94 µg/m³). Long-term analysis showed peak NO_2 levels in 2018 (34.40 µg/m³) in Chattogram, declining to 6.28 µg/m³ by 2024. These findings underscore the necessity for stricter emission regulations and targeted mitigation measures, including the implementation of NO_2-selective catalytic reduction (SCR) using NH_3 over metal oxide and zeolite catalysts. This study provides evidence-based insights to support cleaner air initiatives and sustainable environmental management strategies in Bangladesh.

STUDY AREA & Methodology

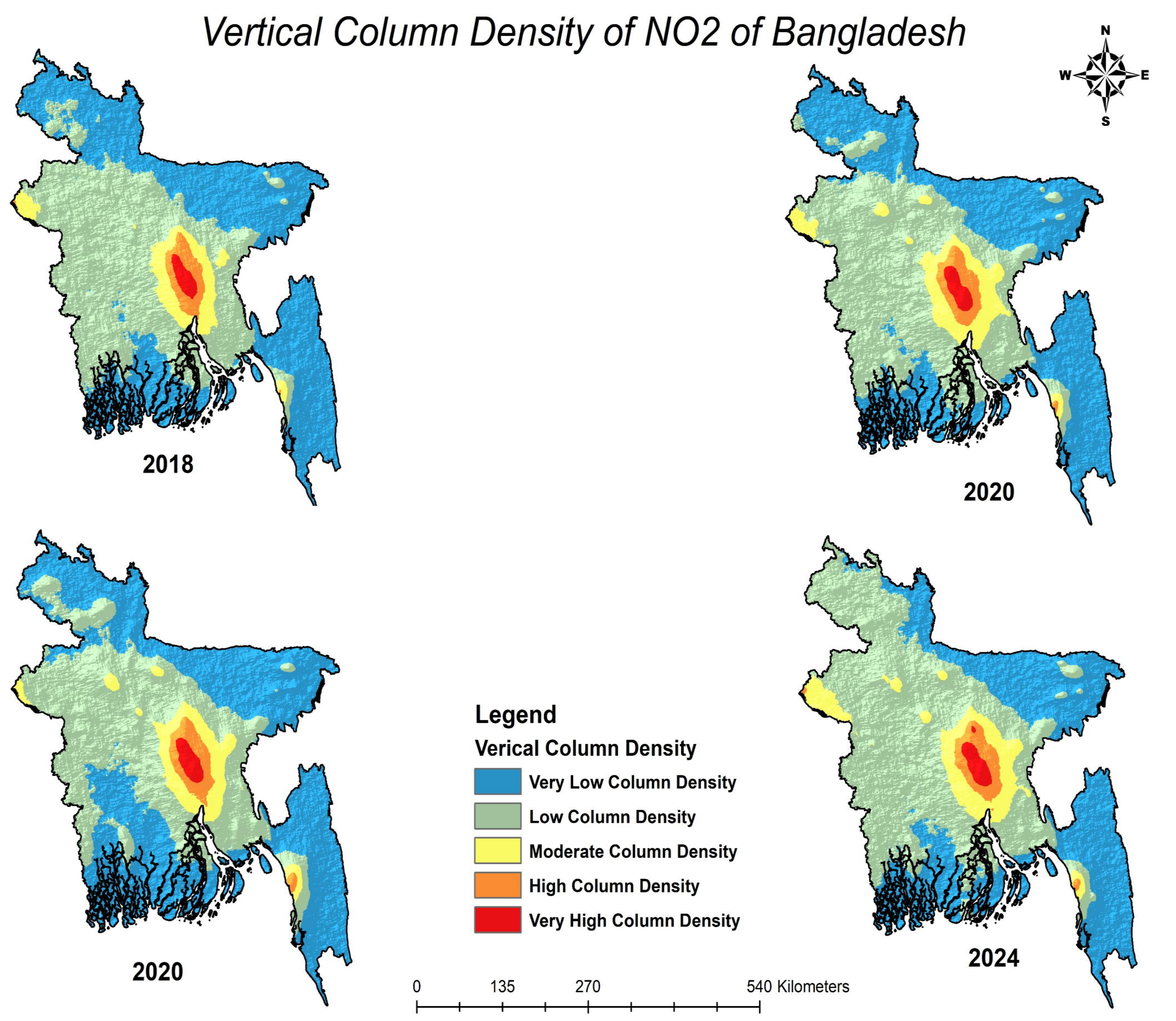
This study investigates the spatio-temporal variability of NO_2 across Bangladesh, a densely populated South Asian country located between approximately 20°–27°N and 88°–92°E within the GBM deltaic system. As shown in the figure, Bangladesh is bordered by India on the west, north, and east, Myanmar to the southeast, and the Bay of Bengal to the south.

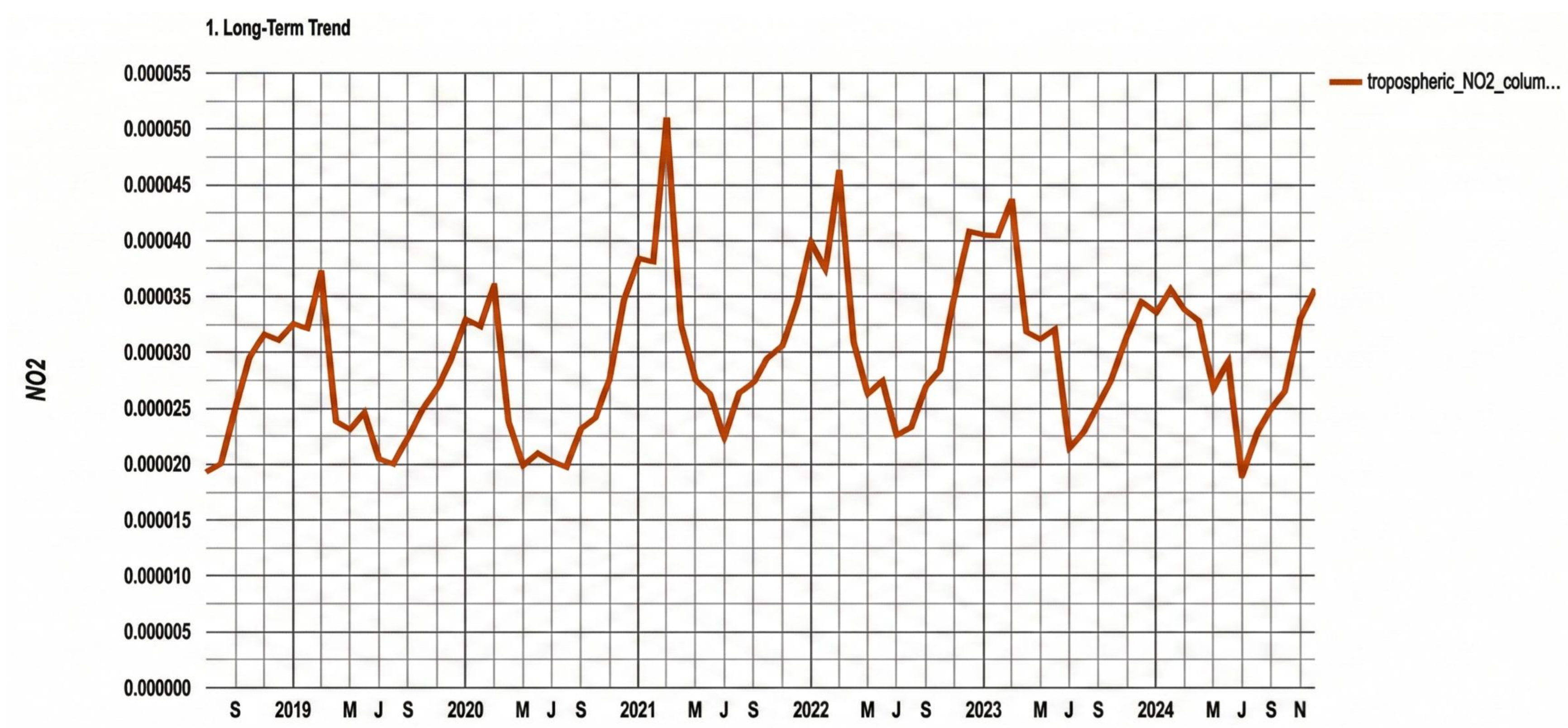






RESULTS & DISCUSSION





CONCLUSION

This study demonstrates pronounced spatial, seasonal, and long-term variability in NO_2 across Bangladesh by integrating DoE ground observations with Sentinel-5P TROPOMI data. The highest concentrations were observed over Dhaka and surrounding industrial zones, with extreme winter peaks reaching 212 µg/m³ in Sylhet (2016). Seasonal analysis showed maximum averages in autumn (35.13 µg/m³), followed by winter (25.67 µg/m³), while November recorded the highest monthly mean (38.94 µg/m³). In contrast, monsoon months exhibited the lowest levels, including 0.46 µg/m³ in Khulna (May 2017). Long-term trends revealed a peak annual mean of 34.40 µg/m³ in 2018 (Chattogram), declining to 6.28 µg/m³ by 2024. These quantified patterns emphasize the urgent need for stricter emission controls and targeted mitigation strategies to sustain recent improvements in air quality.

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