ASSESSMENT OF AIR QUALITY INDEX AND IDENTIFICATION OF HIGH CARBON-SEQUESTERING PLANT SPECIES: A COMPARATIVE STUDY OF URBAN, INDUSTRIAL AND TRANSITION ZONES.

Project Reference No.: *48S_MSC_0277*

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Keywords:

Carbon sequestration, air quality monitoring, high-sequestering tree species, and urban greening strategies.

Introduction:

The widespread use of fossil fuels like coal and natural gas for energy has steadily increased carbon dioxide (CO_2) levels in the atmosphere and triggered long-term changes in the Earth's climate. To tackle this growing problem, natural solutions like carbon sinks—systems that absorb more CO_2 than they emit—offer great potential. Among these, trees rank as the second largest and one of the most effective tools for capturing carbon.

Trees absorb CO_2 from the air through photosynthesis and use it for growth, a process called carbon sequestration. As they grow, they help clean the air, reduce greenhouse gas concentrations, and slow down climate change. However, different tree species store carbon at different rates. Characteristics such as species type, height, and canopy spread all influence how much carbon a tree can absorb and retain.

By identifying which tree species sequester the most carbon, urban planners and environmentalists can make smarter choices in designing green spaces and reforestation projects. Planting the right trees in the right places allows communities to boost the environmental benefits of vegetation and take meaningful steps toward a more sustainable and climate-resilient planet.

Objectives:

1. To monitor air quality (AQI) in selected urban areas: Saneguravahalli, industrial: Peenya industrial areas, and transitional: Peenya areas, to understand pollution dynamics.
2. To analyse the vegetation composition in these areas and identify species with the highest carbon sequestration potential.
3. To propose an urban greening strategy with species recommendations tailored to improve air quality in high-pollution areas.

Methodology:

1. The air quality was monitored on a daily basis over a six-month period using official government data. The monitoring included key parameters such as PM2.5, PM10, NO_2, SO_2, CO, O_3, and the overall Air Quality Index (AQI), capturing seasonal variations and fluctuations.

2. A vegetational composition survey was conducted across three selected areas: Saneguravahalli (Control) , Peenya (Transition) , and the Peenya Industrial Area (Industrial area). Local plant species were mapped and identified.

a. Saneguravahalli is a sublocality in Basaveshwara Nagar, Bangalore West , Bangalore, Bangalore Urban District, Karnataka, India. It has an AQI monitoring station in the Karnataka State Pollution Control Board (KSPCB) campus. It has historically seen lower AQI than any other part of Bengaluru and hence was chosen as the control. The area selected has KSPCB as the epicentre and encompasses a 1km radius around it, with an area of 3.1416 sq. km of surrounding neighbourhoods of Basaveshwaranagar, Rajajinagar, Mahalakshmipuram, Kamalanagara, Kamakshi Palys, Govindrajnagara, and Gayatrinagara (Fig. 1).

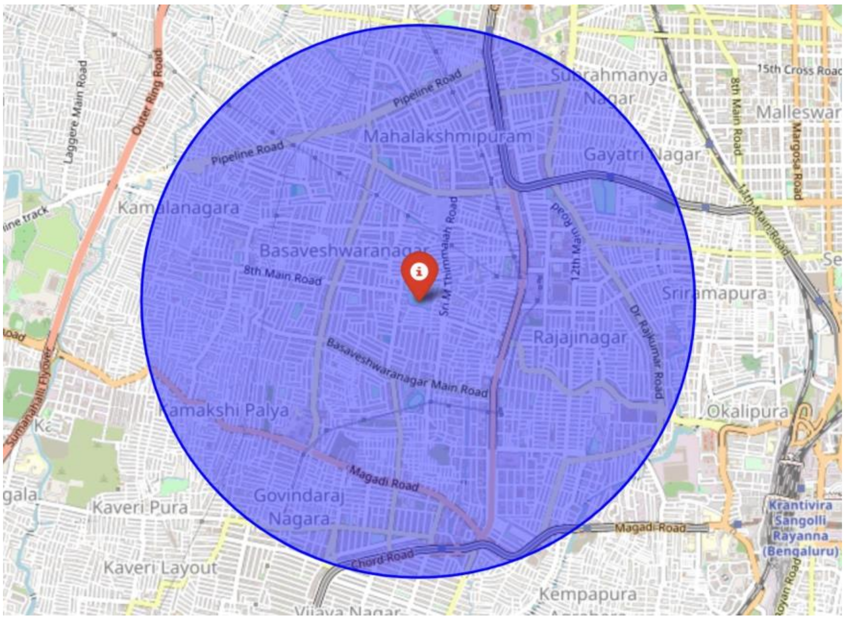

Fig. 1: Map depicting the control area (Saneguravahalli).

b. Peenya is an industrial area of the city of Bengaluru in India (Fig. 4). It is one of the biggest industrial areas in Asia. Peenya lies on the Bangalore-Tumkur Highway. It houses small, medium, and large-scale industries. The total area is about 12.9665 sq. km. Peenya Industrial Estate has now been segregated into 4 phases within Peenya. Hence, Peenya has been taken as the transition zone.

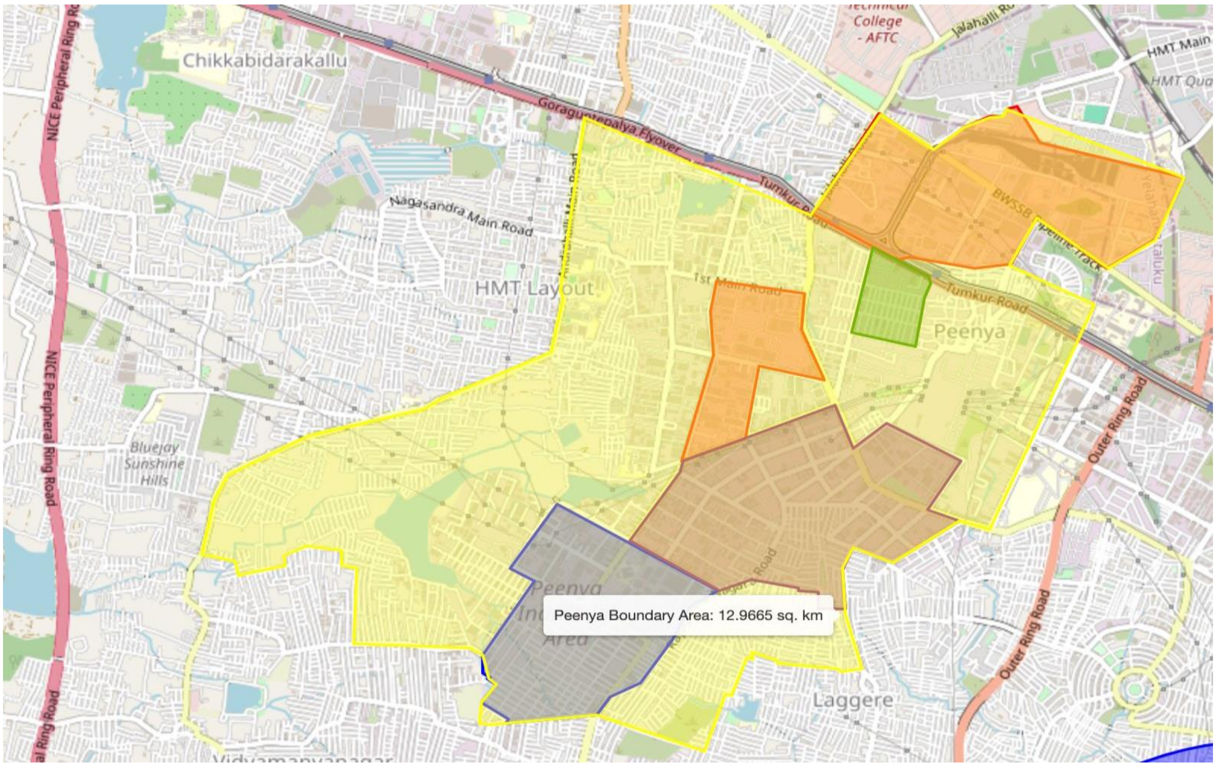

Fig. 4 Map depicting the transition area (Peenya) and Industrial area (Peenya Industrial Phases I-IV)

The industrial area has four phases: Phase I with an area of 1.5189 + 0.50 sq km (Fig. 5), Phase II with an area of 0.2051 sq km (Fig. 6), Phase III with an area of 1.6033 sq km (Fig. 7), and Phase IV with an area of 1.2034 sq km (Fig. 8).

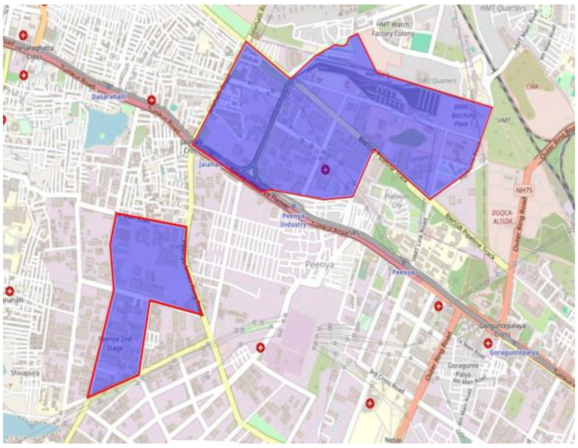

Fig. 5: Map of Peenya Industrial Phase I

Fig. 6: Map of Peenya Industrial Phase II

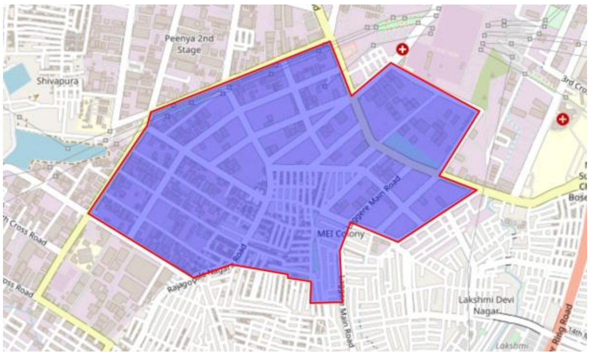

Fig. 7: Map of Peenya Industrial Phase III

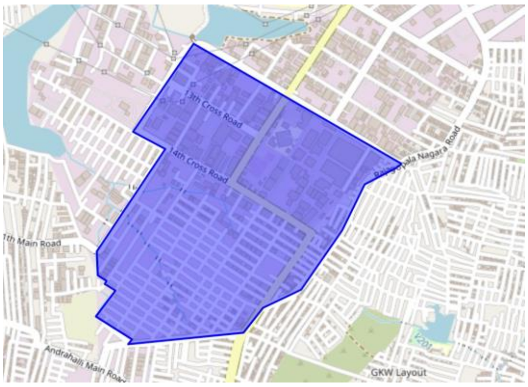

Fig. 8: Map of Peenya Industrial Phase IV

3. For each tree, measurements of height and diameter at breast height (DBH) were recorded to estimate biomass and carbon sequestration potential using standard allometric equations. In addition to field data, secondary sources were consulted to identify high carbon-sequestration tree species.

4. Using the collected measurements, the team calculated above-ground biomass (AGB), below-ground biomass (BGB), total biomass (TB), total dry weight (TDW), total carbon (TC), and corresponding CO_2 weight. These calculations provided quantitative estimates of each species' contribution to carbon storage.

- $AGB = 0.25 \times D^2 \times H$, where, AGB = above ground biomass (pounds)
  D = Diameter (inches)

H = Height (feet)

- BGB = 0.2 × AGB, where, BGB = Below ground biomass (pounds)
  AGB = Above ground biomass (pounds)
- Total Biomass (TB) = AGB + BGB = AGB + 0.2 x AGB = 1.2 × AGB,
  where AGB = Above ground biomass (pounds)
  BGB = Below-ground biomass (pounds)
- Total Dry Weight (TDW) = TB × 0.725, where TB = Total Biomass (pounds)
- Total Carbon (TC) = TDW × 0.5, where TDW = Total Dry Weight (pounds)
- CO_2 weight = TC × 3.67, where, TC = Total carbon
  a. Supplement field data with secondary research on high-sequestration species.

4. In the data analysis phase, the study compares AQI levels across different zones to identify seasonal trends and pollution hotspots. It also evaluates which tree species exhibit the highest carbon sequestration capacity and investigates the correlation between vegetation density or type and improvements in air quality.

Result and Conclusion:

1. Saneguravahalli (Control)

The dataset from Saneguravahall's KSPCB campus and Netaji Park includes 853 trees (Fig. 2) encompassing tree names, family, height (in cm and ft), diameter (in cm), DBH (in cm), above-ground biomass (AGB), below-ground biomass (BGB), total biomass, dry weight, total carbon, and CO_2 equivalent.

The height of the trees ranges from 198 cm to 916 cm, with an average of 654.80 cm. The diameter of the trees ranges from 37 cm to 387 cm, with an average of 198.11 cm. The AGB ranges from 344.61 lbs to 162034.15 lbs, while the BGB ranges from 68.92 lbs to 32406.83 lbs. The total biomass ranges from 413.53 lbs to 194440.98 lbs. The total carbon ranges from 149.90 lbs to 70484.85 lbs, and the CO_2 equivalent ranges from 550.15 lbs to 258679.42 lbs.

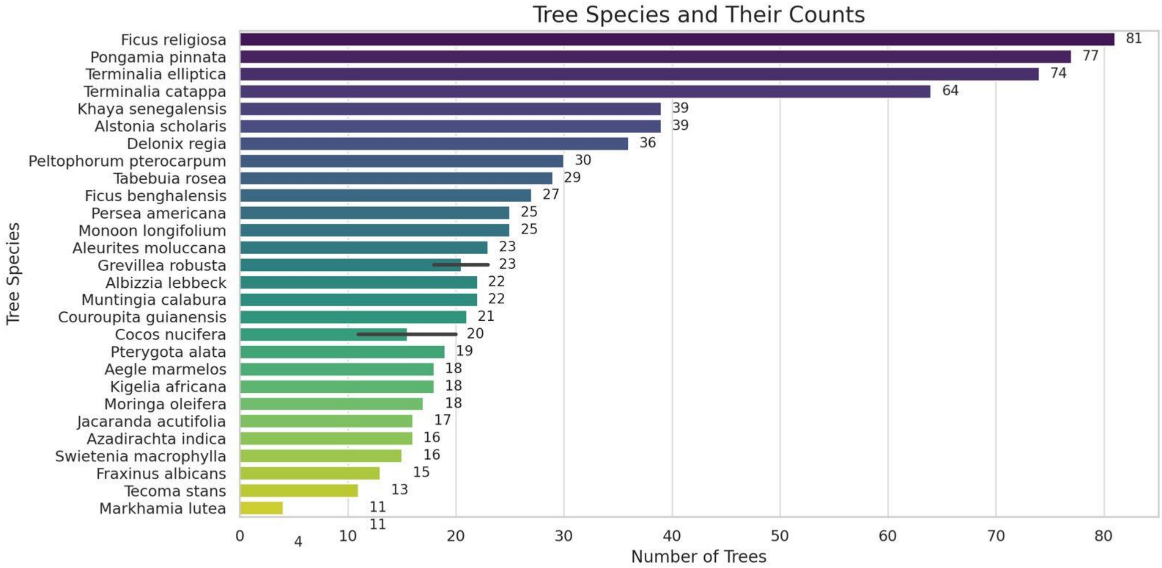

Fig. 2: Species-specific count of the 853 trees surveyed

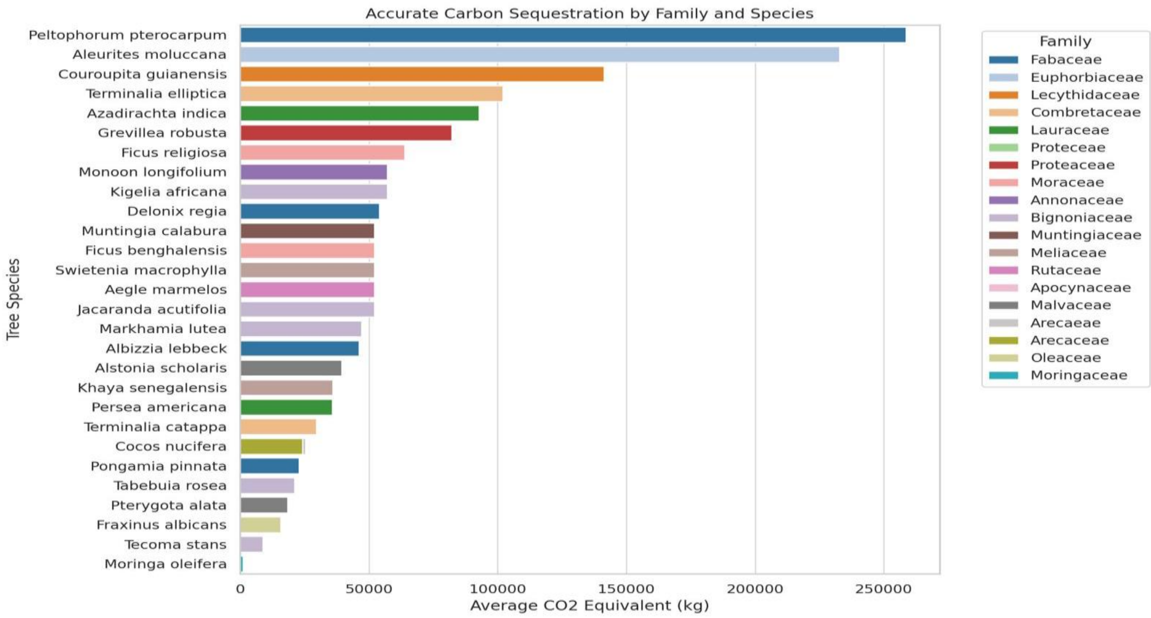

Fig. 3: Carbon sequestration capacity of the 853 trees surveyed according to species and family

2. Peenya and Peenya Industrial Area (Transition and Industrial area)

The dataset from Phase I includes 190 trees (Fig. 7) encompassing tree names, family, height (in cm and ft), diameter (in cm), DBH (in cm), above-ground biomass (AGB), below-ground biomass (BGB), total biomass, dry weight, total carbon, and CO_2 equivalent.

The height of the trees ranges significantly, with values from 900 to 2000 cm. Similarly, the DBH varies, influencing the biomass calculations. Based on the statistics for the entire dataset, the average tree height is approximately 1284.57 cm, with a standard deviation of 754.87 cm, indicating considerable variability in tree sizes. The average DBH is 169.64 cm. The mean AGB is 83042.79 lbs, while the mean BGB is 16608.56 lbs. The 'Total Carbon' column has a mean of 36123.61, suggesting the average carbon storage per tree. The 'CO_2 Equivalent' column, with a mean of 132573.66, indicates the amount of CO_2 sequestered by each tree (Fig. 8)

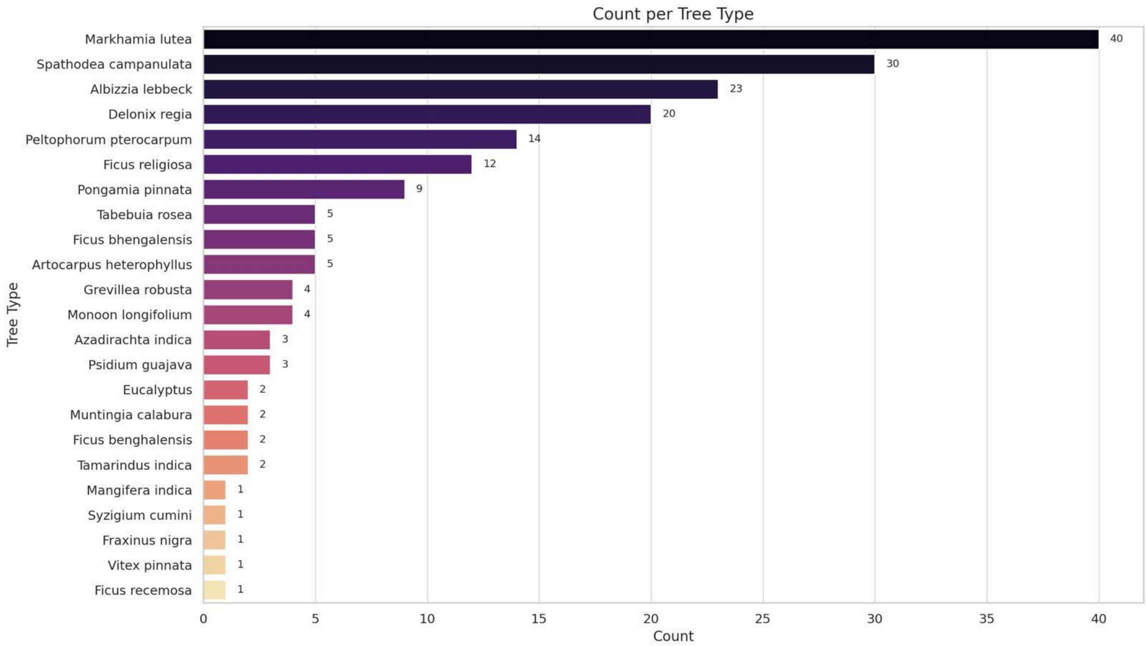

Fig. 7: Species specific count of 190 trees surveyed

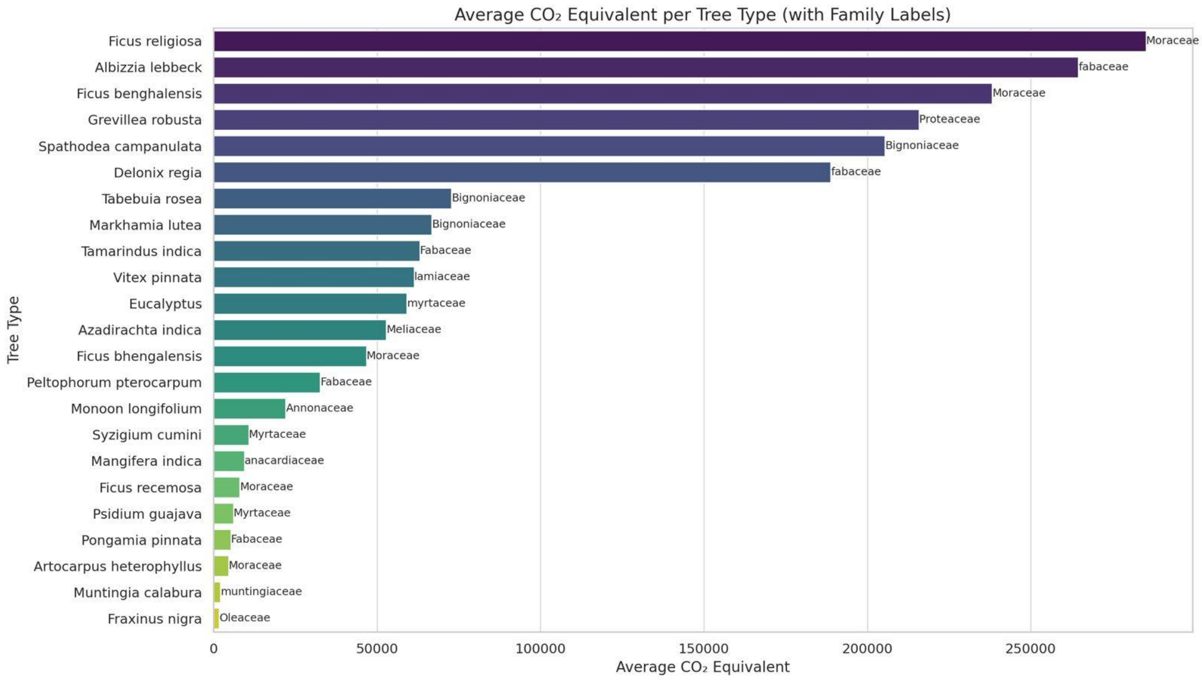

Fig. 8: Carbon sequestration capacity of 190 trees surveyed according to species and family

In conclusion, the highest sequestering trees belong to families Fabaceae and Moraceae. It can be concluded that both the DBH and height play significant roles in the total carbon sequestered. Many private trees were not included in the survey and shall be calculated for carbon sequestered through canopy analysis using GIS applications.

Future Scope:

The future scope of this project includes:

- This model of analysis can be implemented across the country to mitigate one of the most pressing issues of the present day: air pollution. This approach can be used in cities like Delhi, Mumbai, Bengaluru, and many other metropolitan cities with high AQI to improve the air quality.
- Policy changes can be made for future urban development laws, including the recommended species to improve the AQI and to develop greener spaces, aiming towards a more sustainable infrastructure development for growing demands.
- Setting up more AQI monitors across Bengaluru and integrating them with IoT sensors to develop a smart-city dashboard, which will help assess public health correlations with air pollution at micro-levels. It will also aid with evidence-based policy-making to mitigate air pollution.