ML Analysis of Ulaanbaatar's Coal Ban

"Evaluating the Impact of Mongolia's 2019 Raw Coal Ban (RCB) on Air Pollution in Ulaanbaatar using Machine Learning methods"

Course
STATS 201

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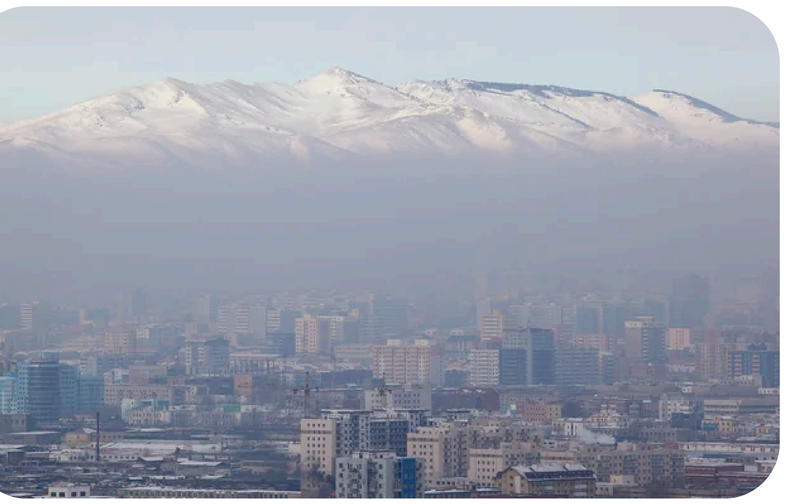
Introduction

Ulaanbaatar the capital city of Mongolia faces extreme winter air pollution, mainly from raw coal use in Ger districts. In 2019, the government banned raw coal to protect public health. While early signs suggest improvements, its true effectiveness remains uncertain. Studying the ban can inform better policies and community-focused solutions.



Objective

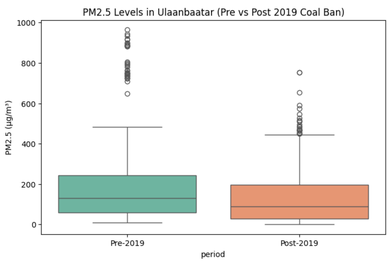
The central research question guiding this study is: "Did the 2019 raw coal ban (RCB) in Ulaanbaatar effectively reduce air pollution levels?" This research aims to evaluate the causal impact of the 2019 raw coal ban on reducing PM2.5 pollution in Ulaanbaatar's Ger districts, providing evidence on the policy's effectiveness and its implications for future clean energy transitions.

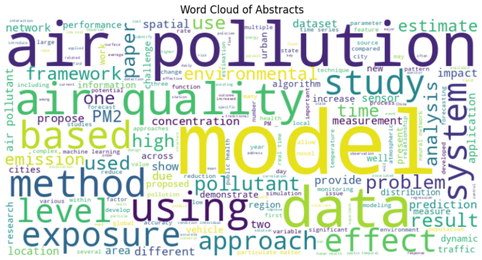
Key Sources

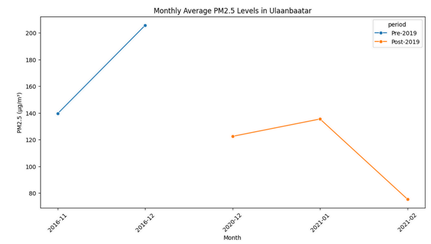
GitHub Repository : https://github.com/Undran/Mongolia-AirPollution-CoalBan

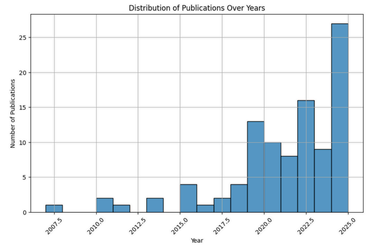
Methodology

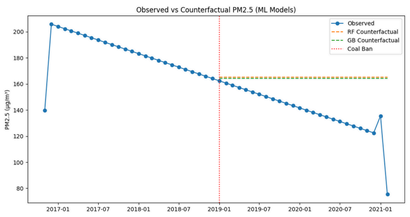
- Two datasets were collected from OpenAQ, that provides air quality measurements for Ulaanbaatar, Mongolia. The datasets cover periods pre-2019 (2015-2018) and post-2019 (2020-2024).
- Descriptive statistics revealed a clear reduction in mean PM2.5 levels following the ban.
- Time series analysis confirmed a consistent downward trend in PM2.5 concentrations post-2019.
- Counterfactual analysis estimated the hypothetical PM2.5 levels had the ban not been implemented, showing a measurable pollution reduction effect.
- Machine learning models (Linear Regression, Random Forest, Gradient Boosting, and XGBoost) were applied for both explanation and prediction of PM2.5 levels.
- Causal inference and policy optimization approaches were explored to assess how clean energy adoption could further accelerate air quality improvements.

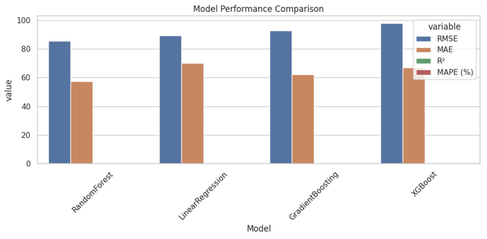












Results

The study demonstrates that the 2019 raw coal ban (RCB) measurably reduced $PM_{2.5}$. (Pre-2019 mean PM2.5: 171.87508610792193 Post-2019 mean PM2.5: 130.09290322580645). The reduction after the coal ban suggests that regulatory interventions can meaningfully alter pollution trajectories, but $PM_{2.5}$ levels still remain far above safe thresholds (WHO), indicating that additional measures are needed. Thus, continued energy transition toward renewables could further improve air quality and public health in Ulaanbaatar.

Analysis

This study contributes to the limited body of research assessing the impact and effectiveness of the Raw Coal Ban (RCB) policy in Mongolia. The analysis highlights the value of open-access datasets for understanding policy outcomes. However, it is important to note that the scope of the analysis was constrained by the availability of relevant data.

Conclusion

The 2019 coal ban in Ulaanbaatar reduced $PM_{2.5}$ levels. Counterfactual modeling shows that, without the ban, pollution would have remained higher. The study contributes to understanding how data-driven analyses and machine learning methods can inform environmental policy and provides a foundation for future research on energy transition and public health in Mongolia.

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