

Annexures

Improving Air Quality Management through Forecasts: A Case Study of Delhi's Air Pollution of Winter 2021

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Annexure 1: Statistical metrics used to evaluate the accuracy of forecasts

Accuracy:

Accuracy of a model is determined as the ratio of number of correct predictions divided by the total number of predictions.

Accuracy = Number of correct predictions / Total number of predictions

Correlation coefficient (r):

The correlation coefficient is defined as the covariance of the variables divided by the product of their standard deviations. Its value can vary from -1 to +1. +1 indicates a perfect positive correlation, whereas -1 implies a perfect negative correlation. A value of r close to 1.0 implies a good agreement between the observed and forecasted values. It is given by the following formula:

$$r = \frac{n \sum_{i=1}^n M_i O_i - \sum_{i=1}^n M_i \sum_{i=1}^n O_i}{\sqrt{n \sum_{i=1}^n M_i^2 - \left(\sum_{i=1}^n M_i\right)^2} \sqrt{n \sum_{i=1}^n O_i^2 - \left(\sum_{i=1}^n O_i\right)^2}}$$

Mean Bias Error (MBE):

The mean bias error determines the average bias (forecast-observed) in the forecast and the observed values. Mean bias error represents the systematic error of a forecast model to under or over forecast. It is given by the formula:

$$MBE = \frac{1}{n} \sum_{i=1}^n (M_i - O_i)$$

Mean Absolute Percentage Error (MAPE):

Mean absolute percentage error is determined using the absolute error in each period divided by the observed values corresponding to that period. Then, averaging those fixed percentages. It is given by the formula:

$$MAPE = \frac{100}{n} \times \sum_{i=1}^n \left| \frac{M_i - O_i}{O_i} \right|$$

Here M_i represents the modelled and O_i represents the observed values

Annexure 2: How meteorology of 2021 compared with 2020 in different phases of winter

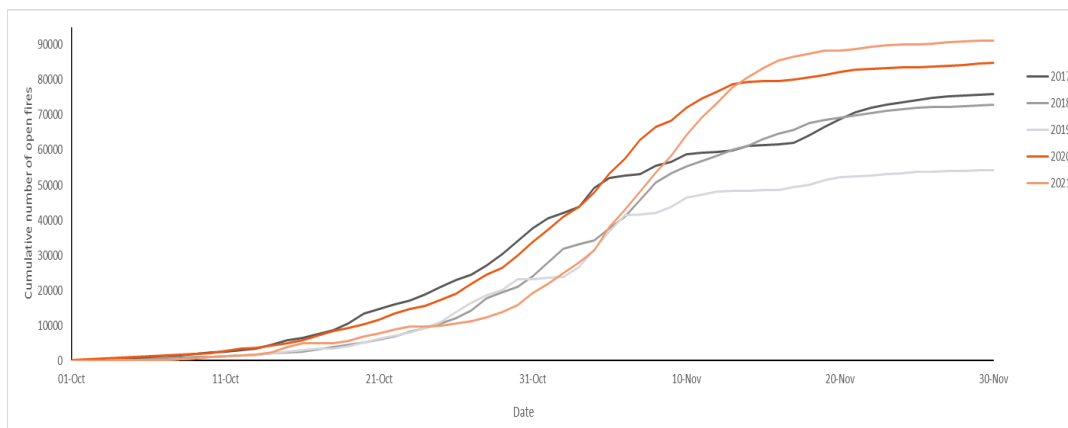
Table A1: Average values of PM_{2.5} and meteorological variables in different phases of winter in 2020 and 2021

Year	Phase	PM _{2.5} (µgm ⁻³)	Wind speed(km/hr)	Temperature (°C)	Number of rainy + trace rain days
2021	Stubble burning	161	7.57	22.54	3
2020	Stubble burning	214	5.47	22.49	0
2021	Post-stubble burning	196	6.20	17.52	3
2020	Post-stubble burning	171	6.80	17.44	5
2021	Peak winter	185	7.13	13.42	12
2020	Peak winter	181	8.44	12.84	6

Source: Authors' analysis; pollutant data from Central Pollution Control Board (CPCB) and meteorological data from European Centre for Medium-Range Weather Forecasts (ECMWF)

Annexure 3: Open fires in Haryana, Punjab and Uttar Pradesh in the period between 1 October and 30 November from 2017 to 2021

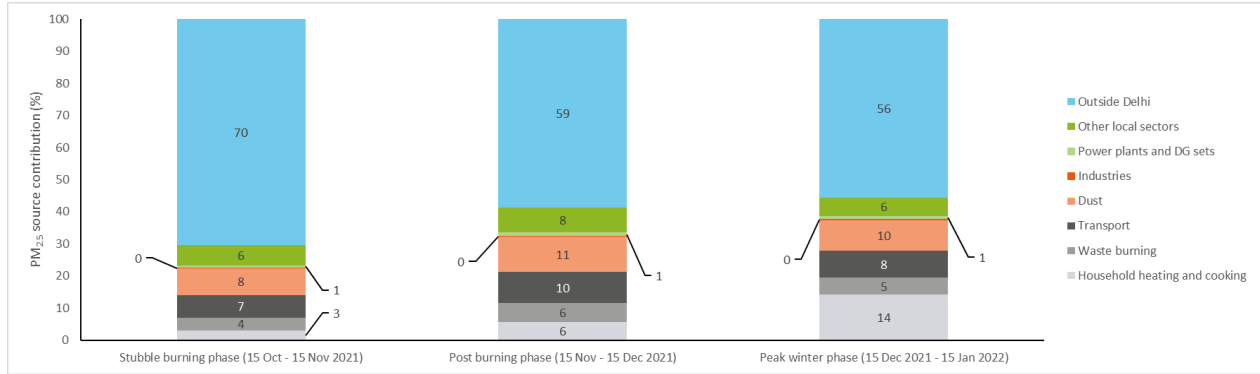
Figure A1: Cumulative count of open fires in Haryana, Punjab and Uttar Pradesh in the period between 1 October and 30 November from 2017 to 2021



Source: Fire count data from NASA FIRMS portal

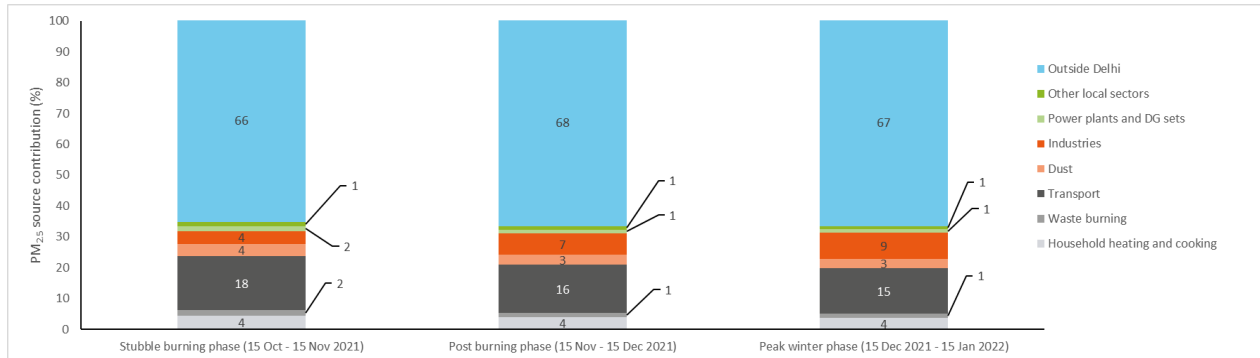
Annexure 4: Source contributions from air quality forecasts

Figure A2: Relative source contributions to the pollution load in Delhi as per UE



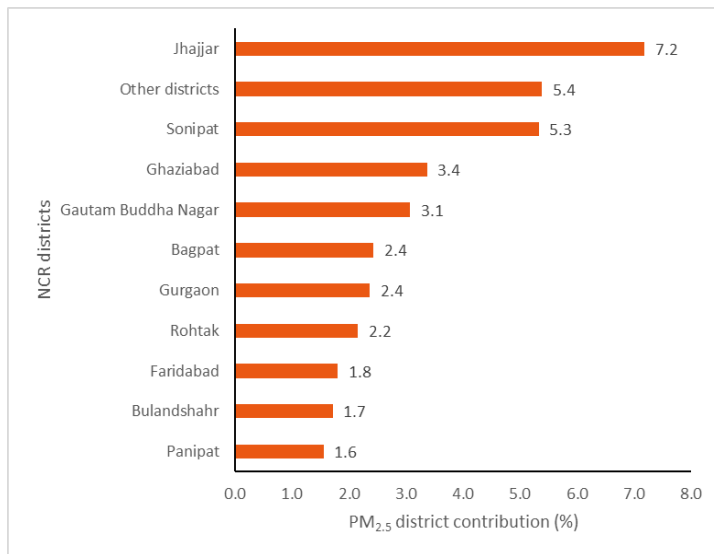
Source: Authors' analysis; Source contribution data from UE

Figure A3: Relative source contributions to the pollution load in Delhi as per DSS



Source: Authors' analysis; Source contribution data from DSS

Figure A4: District-wise relative source contributions to the pollution load in Delhi from the NCR



Source: Authors' analysis; Source contribution data from DSS

Annexure 5: Assessment of the performance of forecasts

Table A2: Performance metrics of the forecasts

Forecast	r	MAPE (%)	MBE
UE	0.69 - 0.80	29.4 - 32.3	(-31.4) - (-52.3)
AQ-EWS 3-day	0.54 - 0.66	28.7 - 37.0	(-3.74) - (-9.49)
AQ-EWS 10-day	0.56 - 0.87	26.4 - 35.4	(-32.2) - (-39.7)

Source: Authors' analysis; Forecast data from AQ-EWS and UE