How to choose and evaluate a sensor?

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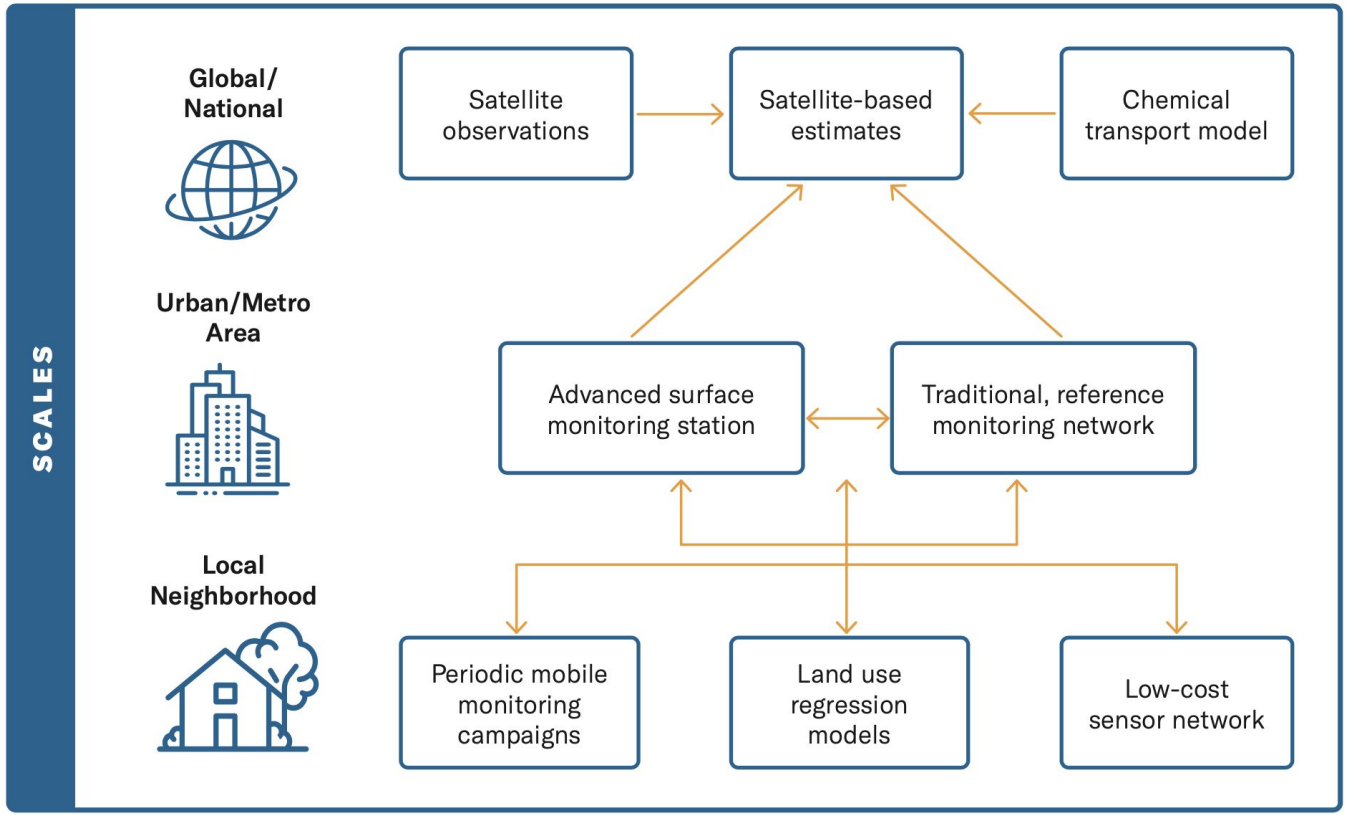
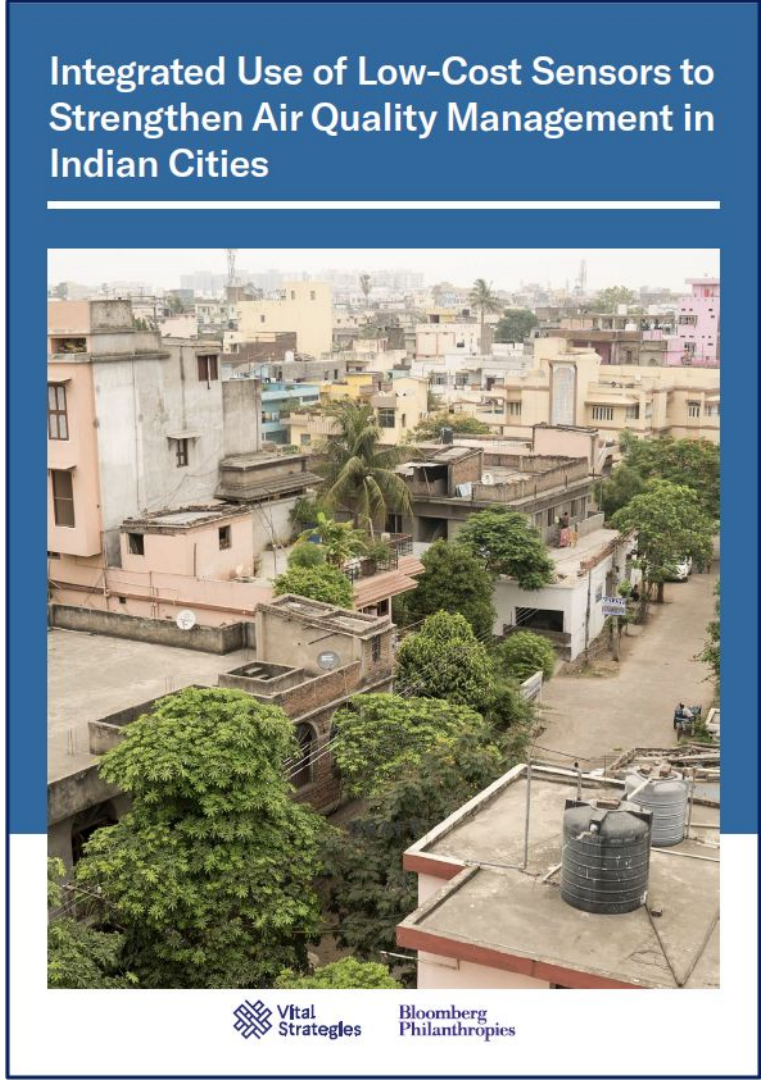
Co-Founder ILK Labs

Integrated Air Quality Monitoring System





Content Highlights

- Selecting / Specifying an Air Sensor
- Performance Metrics
- Assessing Performance
  - Lab and Field Evaluations
  - Other factors for consideration
- Selecting data services
- LCS network design and sensor placement
- Quality assurance and quality control
- Summary guidance to inform tender development and evaluation
- Examples of application of LCS in India

Authors: Meenakshi Kushwaha, Sumi Mehta, Pooja Arora, Timothy Dye, Thomas Matte. Link

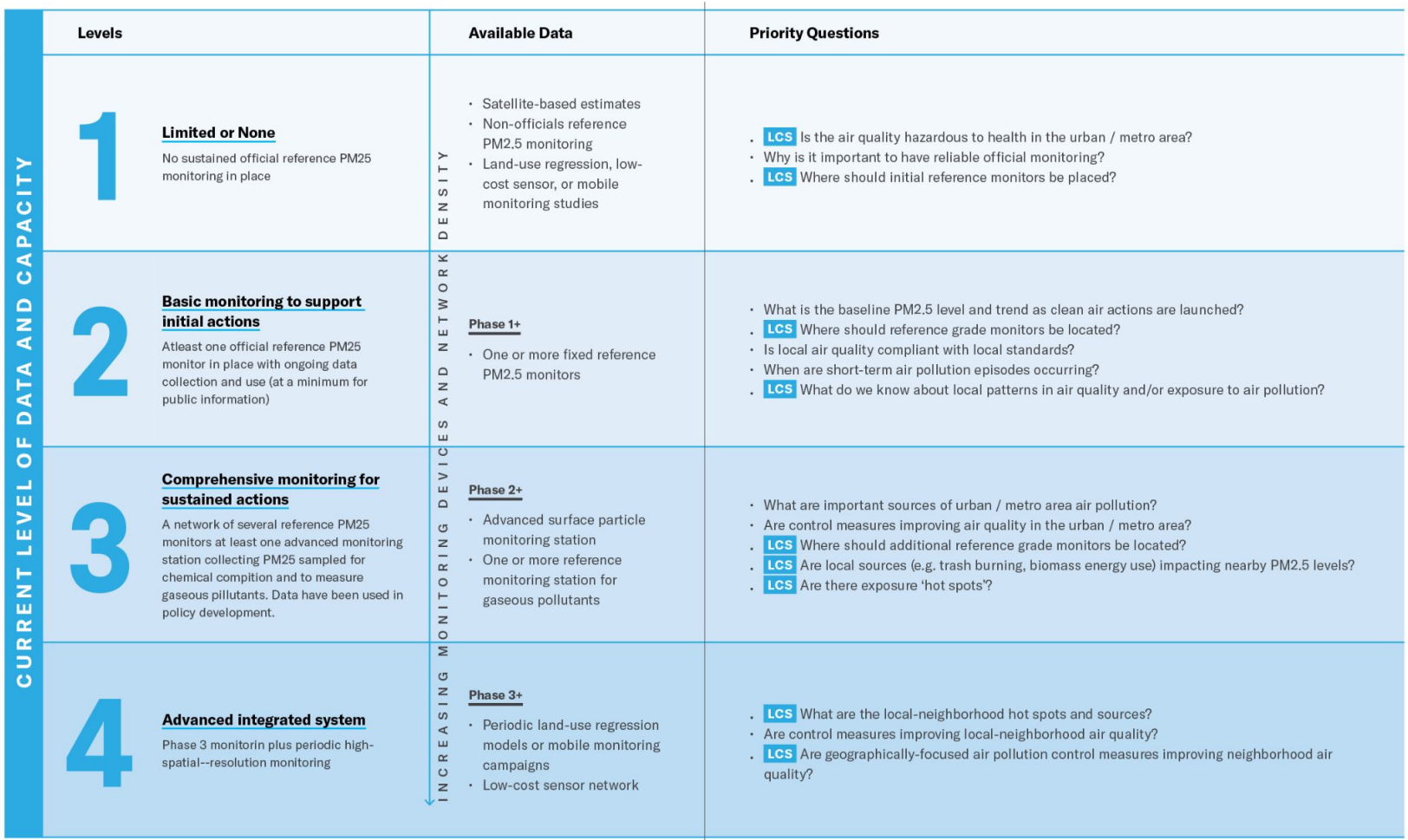


Figure 2. Application of LCS Networks By Current Level of Data and Capacity

Levels		Available Data	Priority Questions
1	**Limited or None** No sustained official reference PM25 monitoring in place	MONITORING DEVICES AND NETWORK DENSITY • Satellite-based estimates • Non-officials reference PM2.5 monitoring • Land-use regression, low-cost sensor, or mobile monitoring studies	• LCS Is the air quality hazardous to health in the urban / metro area? • Why is it important to have reliable official monitoring? • LCS Where should initial reference monitors be placed?
2	**Basic monitoring to support initial actions** Atleast one official reference PM25 monitor in place with ongoing data collection and use (at a minimum for public information)	**Phase 1+** • One or more fixed reference PM2.5 monitors	• What is the baseline PM2.5 level and trend as clean air actions are launched? • LCS Where should reference grade monitors be located? • Is local air quality compliant with local standards? • When are short-term air pollution episodes occurring? • LCS What do we know about local patterns in air quality and/or exposure to air pollution?
3	**Comprehensive monitoring for sustained actions** A network of several reference PM25 monitors at least one advanced monitoring station collecting PM25 sampled for chemical compition and to measure gaseous pillutants. Data have been used in policy development.	**Phase 2+** • Advanced surface particle monitoring station • One or more reference monitoring station for gaseous pollutants	• What are important sources of urban / metro area air pollution? • Are control measures improving air quality in the urban / metro area? • LCS Where should additional reference grade monitors be located? • LCS Are local sources (e.g. trash burning, biomass energy use) impacting nearby PM2.5 levels? • LCS Are there exposure 'hot spots'?

Key Questions for LCS Selections

Application

Does the LCS meet the initial needs for your planned application (e.g. measure pollutants of interest)?

NO →

YES ↓

Performance

Has the LCS been certified, tested, or evaluated by a credible organization?

NO → Select another LCS.

YES ↓

Field Evaluation

Has the LCS been tested in your area under similar pollution and weather conditions?

NO → Can field test be conducted in your region?

NO → Select another LCS.

YES ↓

Support

Does the LCS meet the other requirements for your application? (power, communications, support, etc.)

NO → Select another LCS.

YES ↓

CONSIDER USING THE LCS

Considering the real cost of LCS systems

Purchase Price

Initial cost of monitori equipment

Maintenance

Supplies, parts, service and shipping for repairs

Infrastructure

Structures and suppo infrastructure for installation, security

Data Management

Data management equipment, fees and personnel

Property Leases

If applicable, property lease for installation site

Utilities

Reliable electric power and wireless communications

Personnel

Personnel costs for deployment, calibration and maintenance

Applications

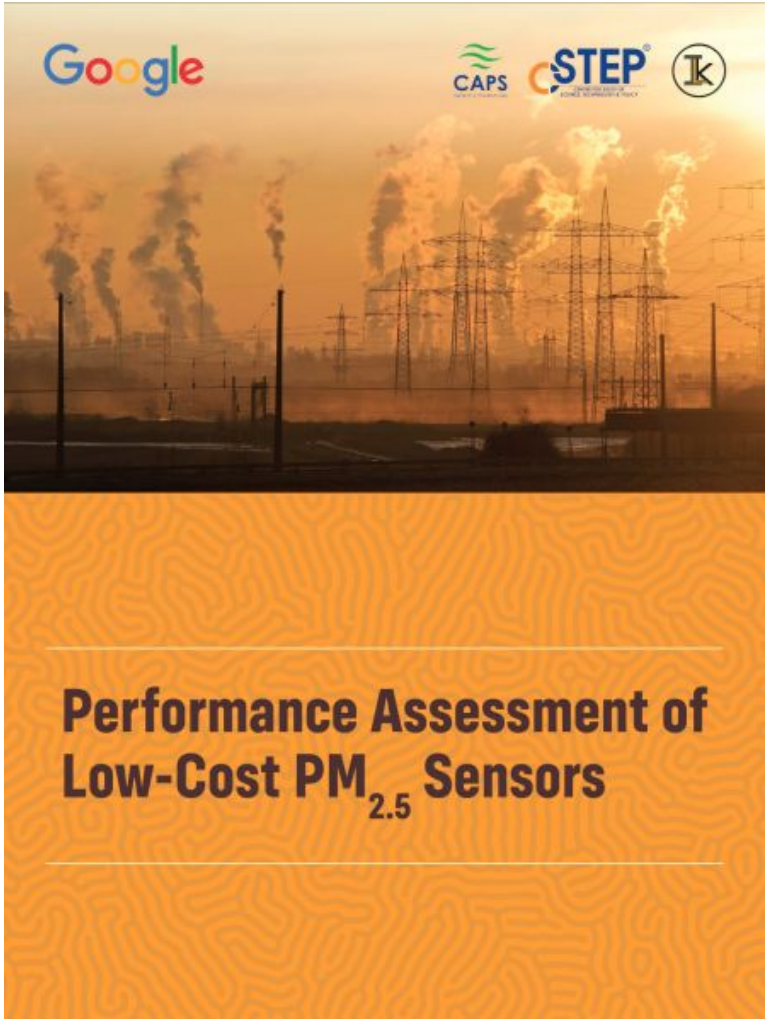
SITING: Characterizing the spatial patterns of $PM_{2.5}$ levels to inform the placement of reference grade monitors

MAPPING AIR QUALITY: Characterizing spatial and temporal exposure gradients across the city

IDENTIFYING HOTSPOTS: Identifying areas with higher concentrations of air pollution

EVALUATING: Assessing the impact of geographically targeted mitigation actions

Note: applications assume data from LCS would be used together with conventional air quality management approaches, and/or along with other innovative methodologies and measurement approaches (e.g. land use regression and remote sensing).

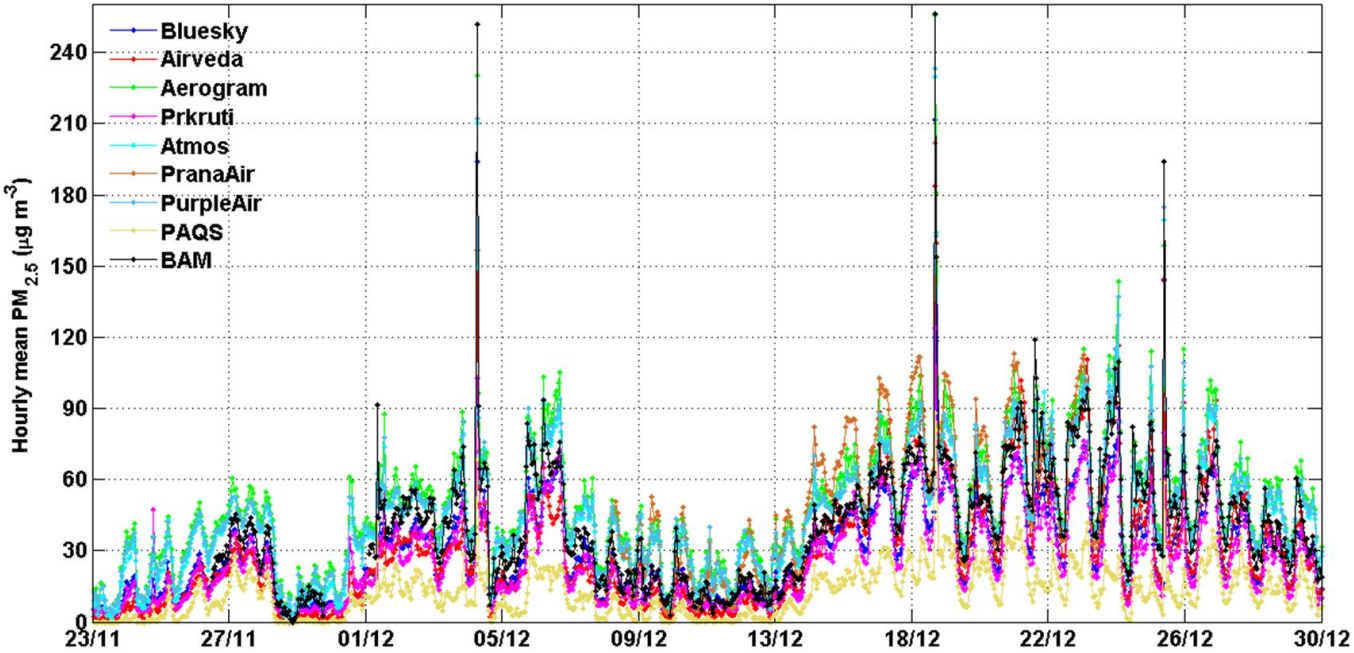


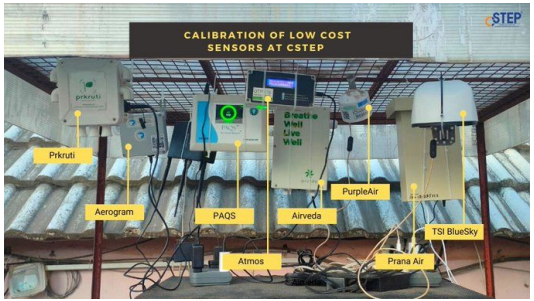
- Used eight different monitors
- Collocated with BAM-1022 (FEM)
- Started data collection in November 2021
- Evaluated Temperature and Relative Humidity

Authors: Sreekanth V, Kushwaha M, Agrawal P, Kulkarni P, Upadhya A R. Link

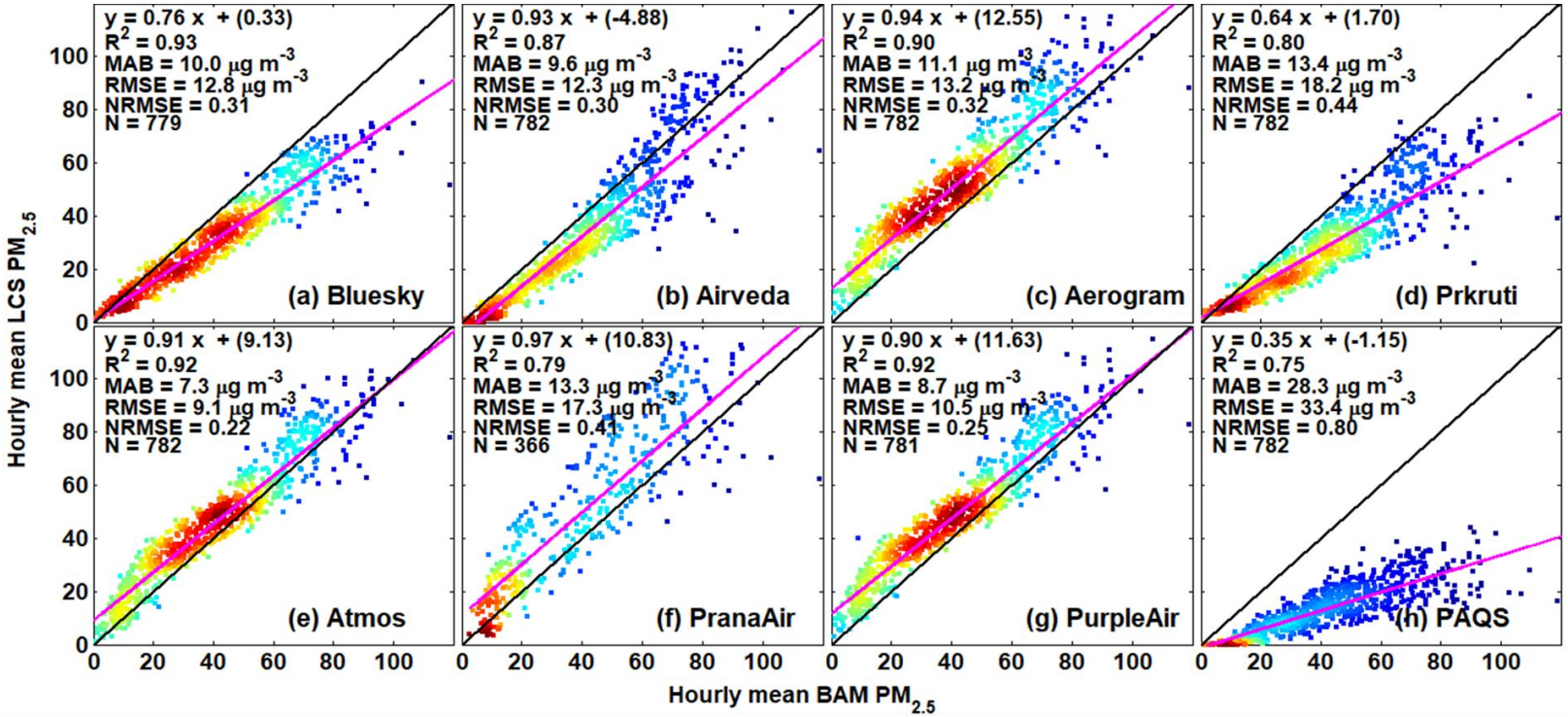
LCS Comparison

LCS Comparison





LCS Comparison



Testing different calibration models

$$url:\ PM_{2.5-BAM} = a \times PM_{2.5-PA} + i + \varepsilon$$

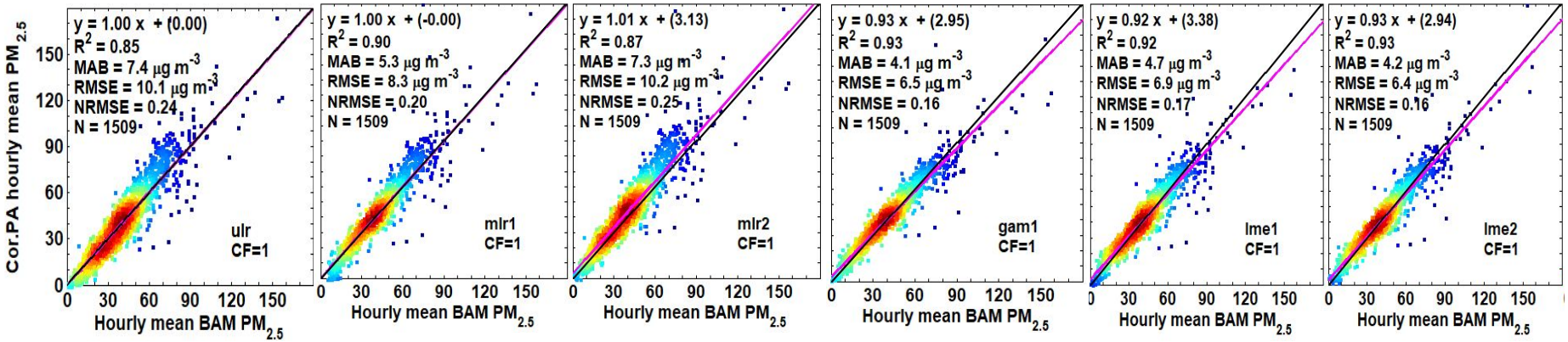
$$mlr1:\ PM_{2.5-BAM} = a \times PM_{2.5-PA} + b \times RH + i + \varepsilon$$

$$mlr2:\ PM_{2.5-BAM} = a \times PM_{2.5-PA} + b \times RH + c \times T + i + \varepsilon$$

$$gam1:\ PM_{2.5-BAM} = s(PM_{2.5-PA}) + s(RH) + s(T) + i + \varepsilon$$

$$lme1:\ PM_{2.5-BAM} = \left(a + (a_{hour} + a_{month})\right)PM_{2.5-PA} + \left(i + (i_{hour} + i_{month})\right) + \varepsilon$$

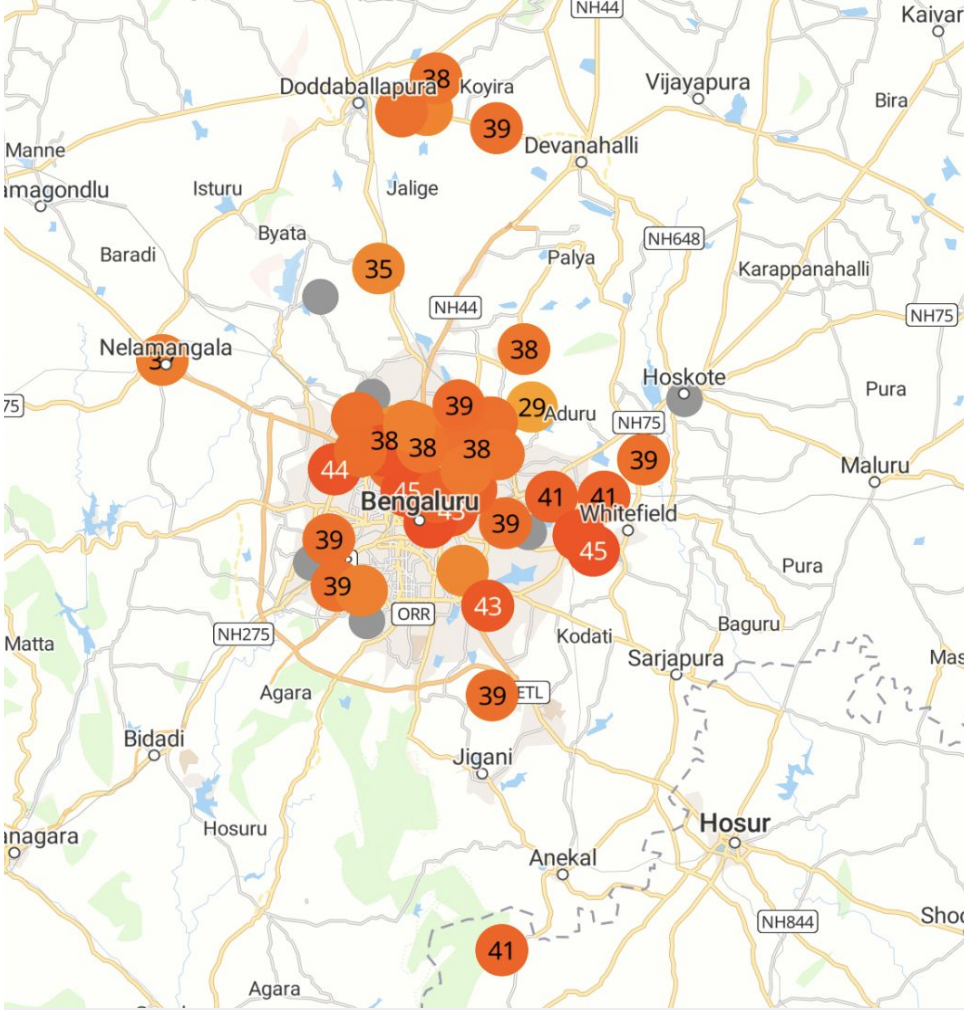
$$lme2:\ PM_{2.5-BAM} = \left(a + (a_{hour} + a_{month})\right)PM_{2.5-PA} + \left(i + (i_{hour} + i_{month})\right) + \varepsilon + b \times RH + \varepsilon$$



Best Practices for Deploying and Maintaining a Low-Cost $PM_{2.5}$ Sensor Network

Supported by

Google



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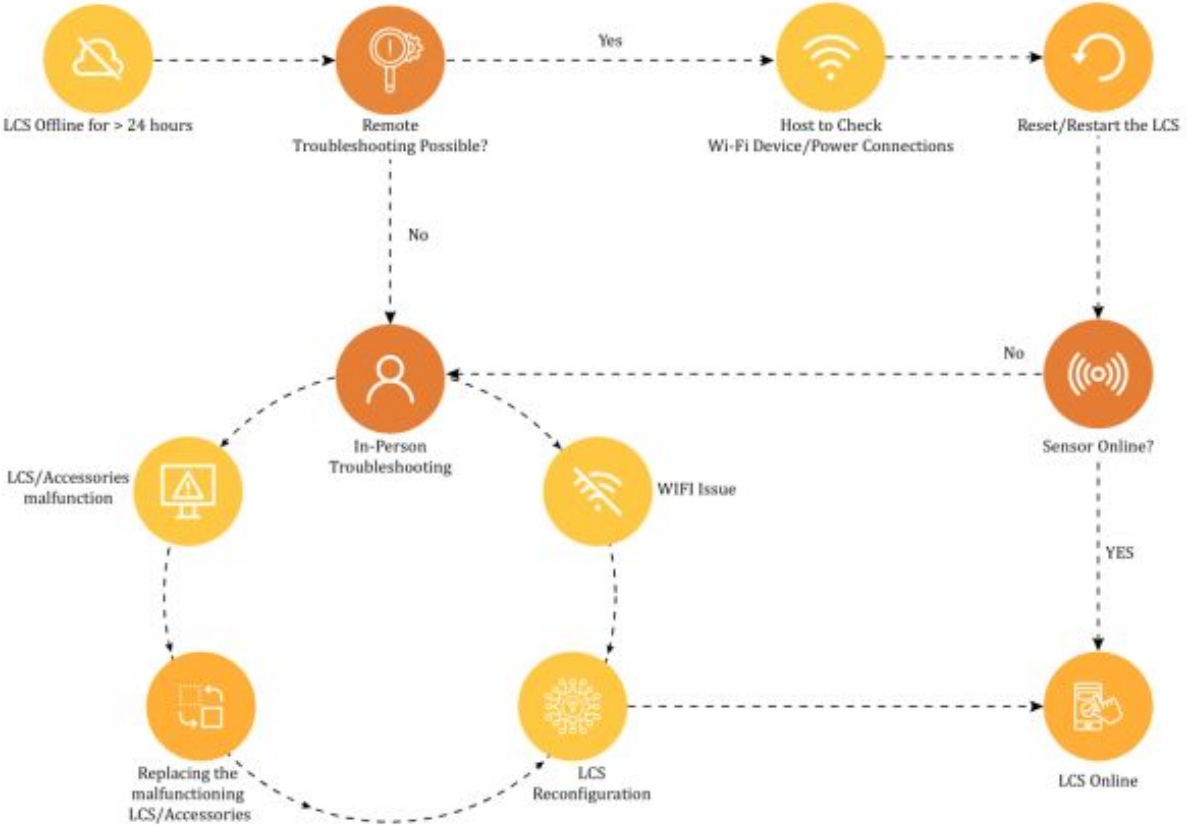
Troubleshooting flowchart



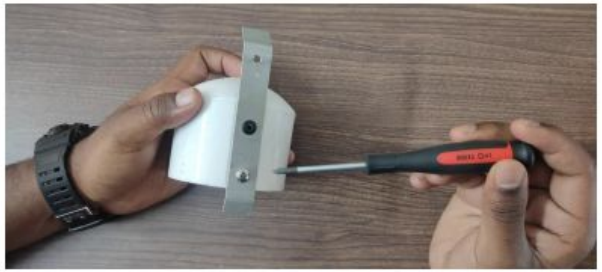
Cost-cutting by using app based delivery + DIY kit

Cost-cutting by refurbishing

7. Appendix: Replacement of Plantower Sensors in PurpleAir

A PurpleAir device can be refurbished by replacing the Plantower laser counters, as long as the meteorological sensor and other electronics are working well. Follow the steps listed below to replace the faulty Plantower set:

1. Unscrew the outer shell.



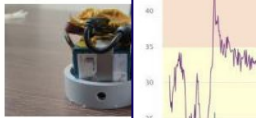
2. Pull the Plantower assembly out by pulling the ring.

3. Remove the sensor unit from the ring and remove the adhesive tape wrapped around the sensor.

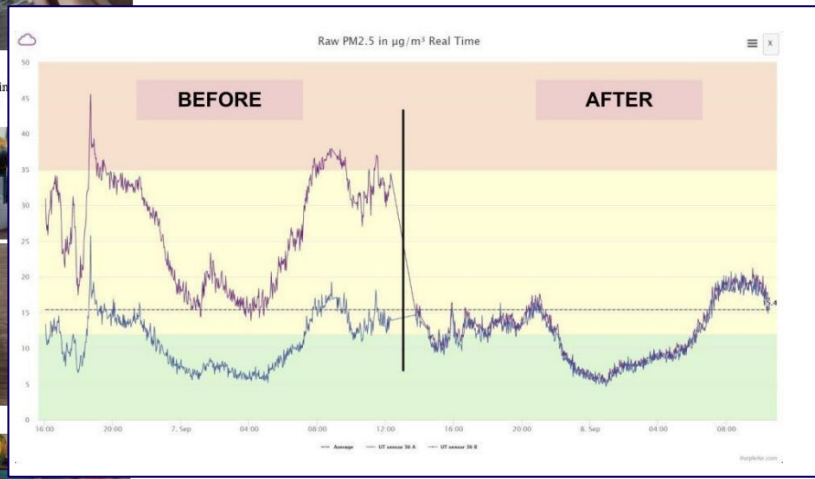
7. Stick the SD card unit, RH and temperature sensor, and the power socket assembly to the new Plantower set.

Note: You can use hot glue to stick the power socket again.

8. Wrap the whole assembly back with the adhesive tape and place it in
push the whole assembly inside the white shell and screw it again.



9. Plantower unit before and after refurbishment



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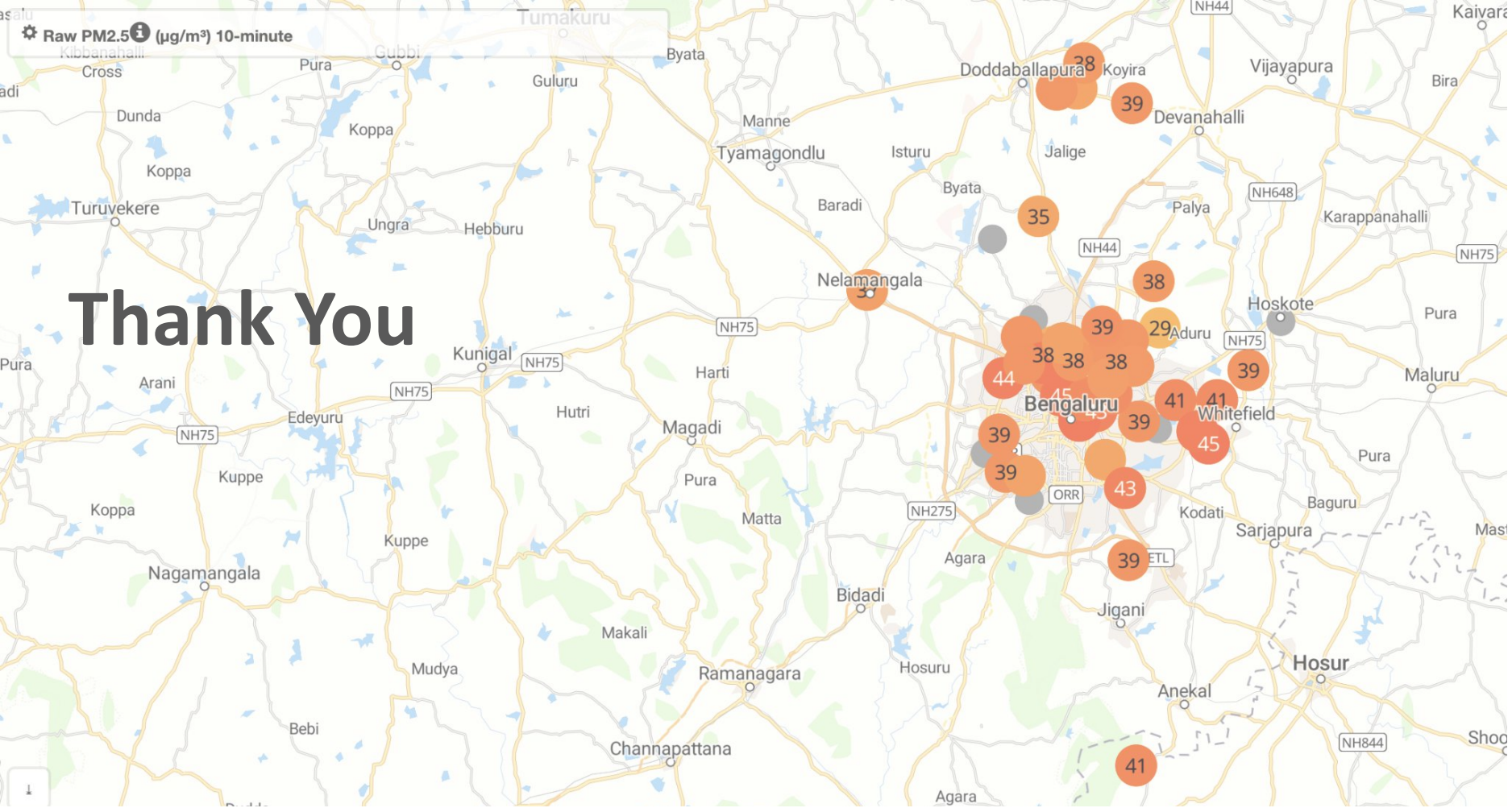

Thank You

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