

A PROJECT REPORT ON

Air Quality Monitoring Network

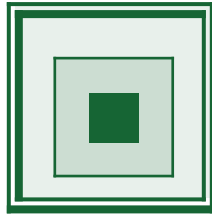
Low-cost sensors mapping pollution across a campus

Submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

in

Environmental Engineering



SUBMITTED BY

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UNDER THE GUIDANCE OF

Dr. M. Fernandes

Department of Environmental Engineering

NORTHFIELD COLLEGE OF ENGINEERING, PUNE

Session 2025–26

CERTIFICATE

This is to certify that the project report entitled “Air Quality Monitoring Network” is a bonafide record of the work carried out by Diya Patel (21CS014), Kabir Verma (21EC022) in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Environmental Engineering during the academic year 2025–26.

The work presented in this report has not been submitted elsewhere for the award of any other degree or diploma.

Dr. M. Fernandes
Project Guide

Dr. V. Raghavan
Head of Department

External Examiner
Date: -----

Declaration

We hereby declare that the project report entitled “Air Quality Monitoring Network” submitted to the Department of Environmental Engineering, Northfield College of Engineering, is a record of original work done by us under the guidance of Dr. M. Fernandes. The results embodied in this report have not been submitted to any other university or institute for the award of any degree.

Place: _____ Date: _____

Diya Patel • Kabir Verma

Acknowledgement

We express our sincere gratitude to our project guide, Dr. M. Fernandes, for constant guidance, encouragement and valuable feedback at every stage of this project.

We thank Dr. V. Raghavan, Head of the Department of Environmental Engineering, and all faculty members for providing the laboratory facilities and support needed to complete this work.

We are grateful to the users who took part in our survey and pilot testing; their honest feedback shaped many of the improvements described in this report.

Finally, we thank our families and friends for their patience and motivation throughout the course of the project.

Abstract

Air quality can change block by block, but most cities have only a few monitors. Air Quality Monitoring Network addresses this gap. Official monitoring stations are sparse and expensive. Low-cost sensor nodes can fill the gaps. The system is organised into 4 stages – measure, transmit, calibrate, visualise – and is built with ESP32 + LoRa, PMS5003, InfluxDB. In our test setup it achieved 0.91 correlation with the reference monitor. This report presents the problem, a review of existing approaches, the requirements, the design and implementation, the testing carried out and the results obtained.

Keywords: ESP32 + LoRa, PMS5003, InfluxDB, Leaflet

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1. Introduction

1.1 Background

Air Quality Monitoring Network addresses a practical problem that affects students, institutions and small organisations alike. Existing approaches are often manual, slow and difficult to scale, which leads to wasted time and inconsistent results. Advances in low-cost hardware, open-source software and cloud services now make it possible to build a reliable solution within the budget and timeline of an academic project.

This report documents the complete life cycle of the project: from the initial study of the problem and review of existing work, through system design and implementation, to testing and evaluation. Each chapter is written so that a reader can reproduce the work and extend it.

1.2 Motivation

The motivation for this project came from direct observation. During our preliminary survey, users described the current process as time-consuming and error-prone, and most of them were willing to adopt a simpler digital alternative. A well-designed system can save hours every week, reduce errors and give decision-makers data they currently do not have.

1.3 Problem Statement

Air quality can change block by block, but most cities have only a few monitors. The key problems identified during our preliminary study are:

- Sparse data — One station may cover a whole district.
- High cost — Reference monitors cost lakhs of rupees each.
- Low awareness — People rarely see local, live readings.

1.4 Objectives

The project was planned around the following objectives:

1. Build nodes measuring PM2.5, PM10, CO₂ and humidity
2. Calibrate against a reference instrument
3. Publish a live campus air-quality map
4. Send alerts when levels cross safe limits

1.5 Scope of the Project

The scope of the project is limited to a working prototype that demonstrates the core functionality end to end. Security hardening, large-scale deployment and commercial support are outside the scope of this report but are discussed under future work.

1.6 Organisation of the Report

- Chapter 2 reviews existing work and identifies the research gap.
- Chapter 3 analyses the requirements and the feasibility of the project.
- Chapter 4 describes the system design, architecture and data design.
- Chapter 5 explains the implementation of each module.
- Chapter 6 presents the testing strategy, test cases and results.
- Chapter 7 discusses the results and limitations.
- Chapter 8 covers project management: roles, schedule, risks and budget.
- Chapter 9 describes deployment, maintenance and impact.
- Chapter 10 concludes the report and outlines future work.

2. Literature Review

2.1 Existing Work

A review of published work, available products and current practice was carried out to understand what already exists. Table 2.1 summarises representative approaches.

Study / system	Approach	Limitation
Kim et al.	Low-cost PM sensors	Drift without calibration
City AQ networks	Dense sensor grids	Proprietary platforms
Patel & Joshi	LoRa-based nodes	Small pilot only

Table 2.1: Summary of existing work

2.1.1 Kim et al.

Kim et al. follows an approach based on low-cost PM sensors. This works well in controlled conditions and shows that the core idea is practical. However, the approach is limited because it is drift without calibration. For our users this limitation matters, which is why the proposed system treats it as a design requirement rather than an afterthought.

2.1.2 City AQ networks

City AQ networks follows an approach based on dense sensor grids. This works well in controlled conditions and shows that the core idea is practical. However, the approach is limited because it is proprietary platforms. For our users this limitation matters, which is why the proposed system treats it as a design requirement rather than an afterthought.

2.1.3 Patel & Joshi

Patel & Joshi follows an approach based on LoRa-based nodes. This works well in controlled conditions and shows that the core idea is practical. However, the approach is limited because it is small pilot only. For our users this limitation matters, which is why the proposed system treats it as a design requirement rather than an afterthought.

2.2 Research Gap

Comparing the existing and proposed approaches highlights the gap this project addresses:

Existing system	Proposed system
Few official stations	Dense low-cost node network
Hourly, delayed data	Minute-level live map
No local alerts	Threshold alerts

*Table 2.2: Existing versus proposed system***Gap addressed**

No low-cost option combines dense low-cost node network with minute-level live map.
Air Quality Monitoring Network is designed to close that gap.

3. Requirement Analysis

3.1 Requirement Gathering

Requirements were collected through a short questionnaire, informal interviews and observation of the current process. Respondents were asked how they handle the task today, what problems they face and what they would expect from a better system. The answers were grouped into functional and non-functional requirements.

3.2 Functional Requirements

ID	Module	Requirement	Priority
FR-01	Measure	PMS5003 and CO ₂ sensors in each node	High
FR-02	Transmit	LoRa sends readings to a gateway	High
FR-03	Calibrate	Correction model on the server	Medium
FR-04	Visualise	Live map and alerts	Medium
FR-05	System	Build nodes measuring PM2.5, PM10, CO ₂ and humidity	Medium
FR-06	System	Calibrate against a reference instrument	Medium
FR-07	System	Publish a live campus air-quality map	Medium

Table 3.1: Functional requirements

3.3 Non-functional Requirements

Quality	Requirement
Performance	Typical responses within 1 min under normal load
Reliability	Runs continuously for at least 7 days in the pilot without manual restart
Usability	A new user completes the main task within 5 minutes without training
Security	Role-based access; passwords stored as salted hashes; data backed up daily
Maintainability	Modular code with configuration kept in one file and documented interfaces
Cost	Hardware and hosting within the budget of a small institution (0.91)

Table 3.2: Non-functional requirements

3.4 Hardware and Software Requirements

Component	Used for
ESP32 + LoRa	Node controller and radio
PMS5003	Particulate matter sensor
InfluxDB	Time-series storage
Leaflet	Interactive map
Development PC	Intel i5 / 8 GB RAM or equivalent, Windows or Ubuntu
Tools	Git for version control, VS Code, a spreadsheet for test logs

Table 3.3: Hardware and software requirements

3.5 Feasibility Study

Technical feasibility

All components used — ESP32 + LoRa, PMS5003, InfluxDB, Leaflet — are mature, well documented and available in India. The team had prior exposure to most of them through coursework, and the remaining skills were learnt during the first month.

Economic feasibility

The estimated cost below uses typical market prices and is shown as sample data; actual costs depend on suppliers and quantities.

Item	Qty	Unit cost (₹)	Total (₹)
ESP32 + LoRa	1	—	—
PMS5003	1	—	—
InfluxDB	1	—	—
Leaflet	1	—	—
Miscellaneous (wires, casing, hosting)	1	—	—
Total (sample)			₹ —

Table 3.4: Estimated project cost (sample)

Operational feasibility

Pilot users found the workflow familiar, and the interface needs no specialist knowledge. Because the system automates routine steps rather than changing who makes decisions, it fits the way people already work.

3.6 Use Cases

ID	Actor	Use case	Outcome
UC-01	User	Sign in and view the dashboard	Credentials verified; dashboard shown
UC-02	User	Build nodes measuring PM2.5, PM10, CO ₂ and humidity	Task completed and recorded
UC-03	Administrator	Configure thresholds, users and settings	Settings saved and applied
UC-04	System	Live map and alerts	Notification or report generated
UC-05	Administrator	Export reports for a date range	CSV/PDF report downloaded

Table 3.5: Main use cases

4. System Design

4.1 Proposed System

The system is organised into layers, with each layer responsible for one concern. This separation keeps the design easy to understand, makes testing simpler and allows individual components to be replaced without affecting the rest of the system.

Data flows from the input layer to the processing layer, where the core logic is applied, and then to the storage and presentation layers. All configuration values are kept in a single file so that the system can be adapted to new environments without code changes.

4.2 System Architecture

Solar-powered nodes send readings over LoRa to a gateway, which forwards them to a time-series database. A calibration model corrects drift before the map is updated.

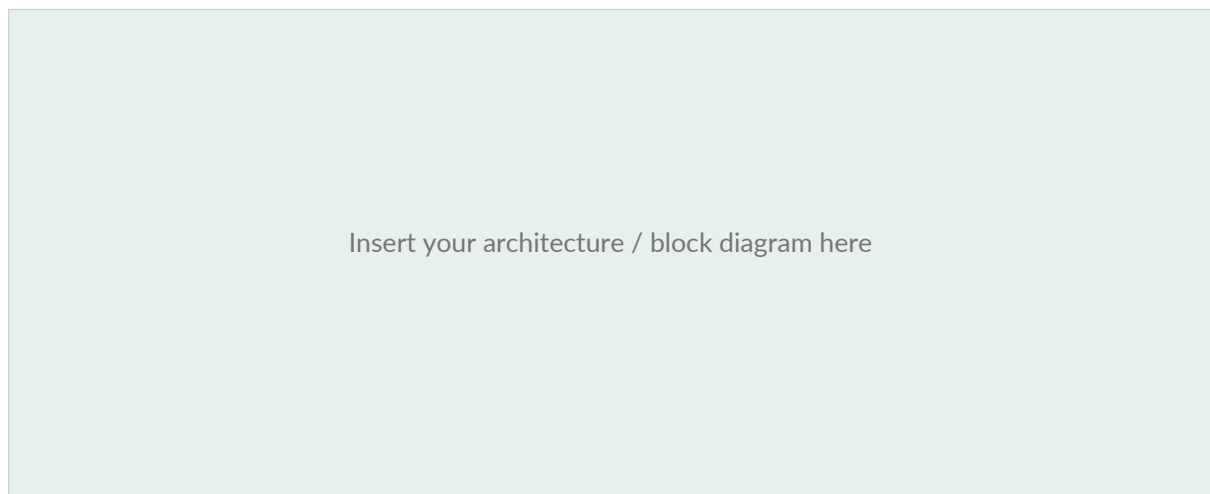


Figure: System architecture

Stage	What happens
Measure	PMS5003 and CO ₂ sensors in each node
Transmit	LoRa sends readings to a gateway
Calibrate	Correction model on the server
Visualise	Live map and alerts

4.3 Technology Stack

Component	Purpose
ESP32 + LoRa	Node controller and radio

Component	Purpose
PMS5003	Particulate matter sensor
InfluxDB	Time-series storage
Leaflet	Interactive map

Table 4.1: Technology stack

4.4 Data Flow

The data flow follows the architecture from left to right. Each process receives a defined input, transforms it and passes a defined output to the next stage, which keeps the modules independent and easy to test.

Process	Input from	Main action	Data store
Measure	User / environment	PMS5003 ...	Logs, database
Transmit	Measure output	LoRa ...	Logs, database
Calibrate	Transmit output	Correction ...	Logs, database
Visualise	Calibrate output	Live ...	Logs, database

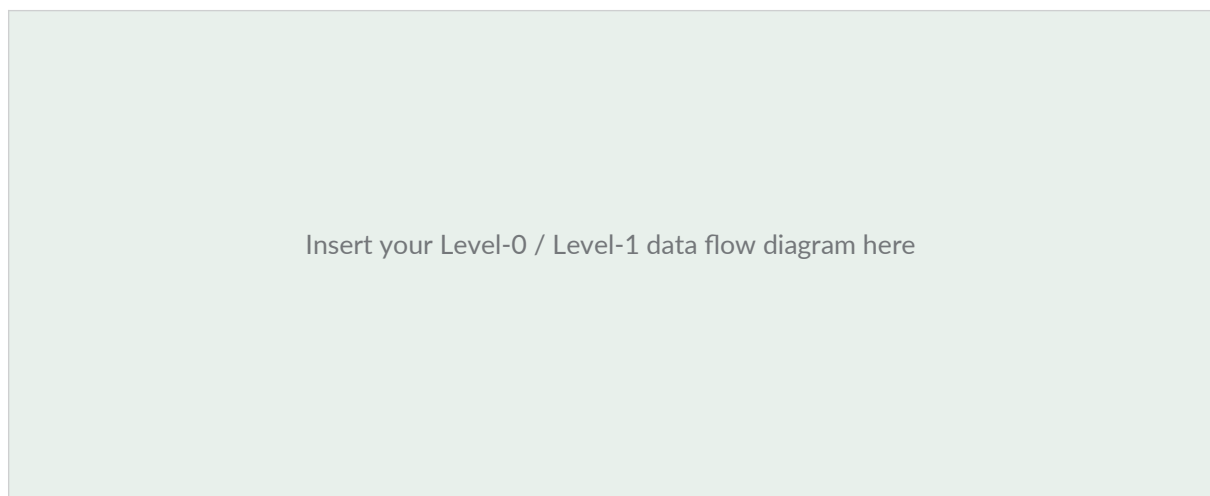


Figure: Data flow diagram

4.5 Data Design

Field	Type	Description
id	Integer (PK)	Unique record identifier
created_at	Timestamp	When the record was created
user_id	Integer (FK)	User who created or owns the record
source	Text(40)	Origin of the data (measure stage)

Field	Type	Description
value	Decimal(10,2)	PM2.5 ($\mu\text{g}/\text{m}^3$)
status	Enum	pending / processed / flagged
notes	Text	Free-text remarks added by staff

Table 4.2: Data dictionary

4.6 User Interface Design

Wireframes were drawn on paper first and then built as clickable prototypes. Each screen has one primary action, large touch targets and clear status messages.

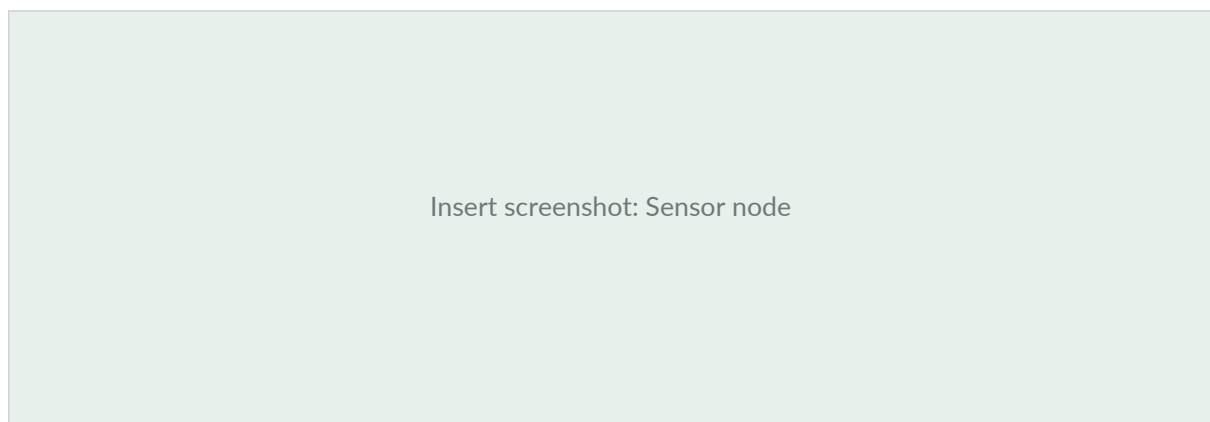


Figure: Sensor node – Weatherproof enclosure with solar panel

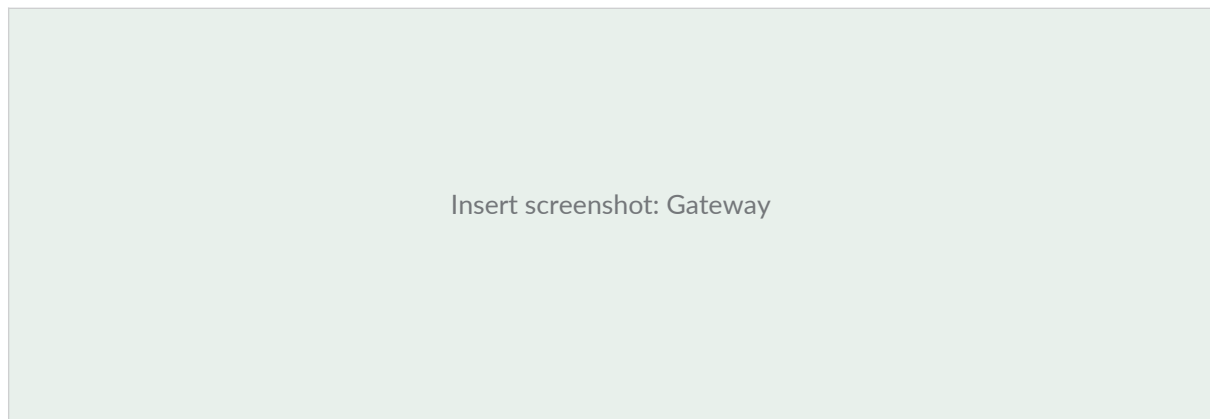
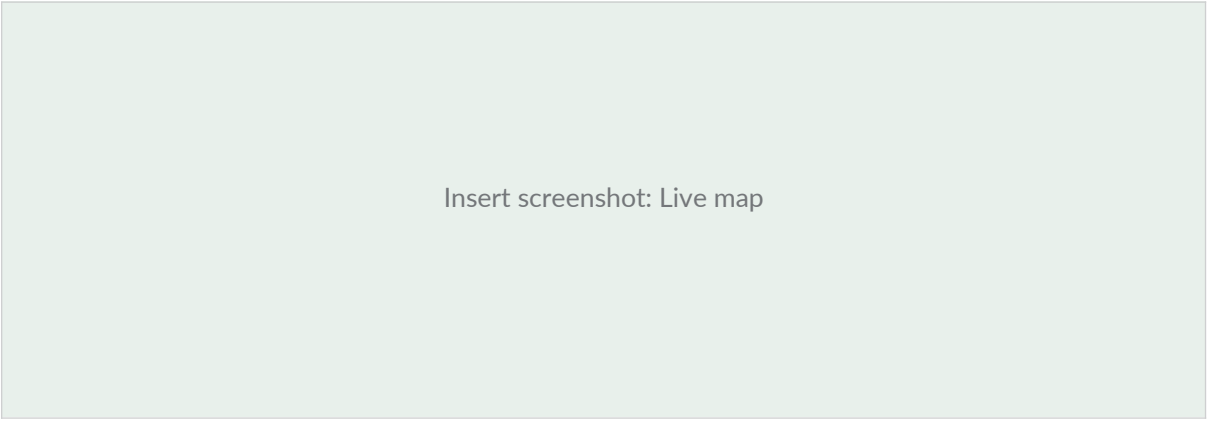


Figure: Gateway – Rooftop LoRa receiver



Insert screenshot: Live map

Figure: Live map — Colour-coded AQI by location

5. Implementation

5.1 Methodology

The project followed an iterative development model. Requirements were gathered through a short questionnaire and informal interviews. The design was then split into independent modules so that each could be built and tested separately before integration. Weekly reviews with the project guide helped keep the work on schedule.

Each module was developed with clear inputs and outputs. Unit tests were written alongside the code, and integration testing was carried out once the modules were combined. Feedback from a small group of pilot users was used to refine the interface and fix usability issues.

5.2 Project Timeline

Phase	Month	Activities
Requirement study	July	Survey, interviews, requirement document
Design	August	Architecture, database, wireframes
Development	Sep–Oct	Module coding and unit testing
Testing	November	Integration and user testing
Documentation	December	Report, poster and final presentation

Table 5.1: Project timeline

5.3 Module Description

5.3.1 Measure module

PMS5003 and CO₂ sensors in each node. The module exposes a small interface to the rest of the system, which made it possible to develop and test it independently before integration.

- Input: data from the field or user
- Processing: PMS5003 and CO₂ sensors in each node
- Output: passed to transmit
- Errors: logged with a timestamp and shown as a clear message

5.3.2 Transmit module

LoRa sends readings to a gateway. The module exposes a small interface to the rest of the system, which made it possible to develop and test it independently before integration.

- Input: data from the previous stage

- Processing: loRa sends readings to a gateway
- Output: passed to calibrate
- Errors: logged with a timestamp and shown as a clear message

5.3.3 Calibrate module

Correction model on the server. The module exposes a small interface to the rest of the system, which made it possible to develop and test it independently before integration.

- Input: data from the previous stage
- Processing: correction model on the server
- Output: passed to visualise
- Errors: logged with a timestamp and shown as a clear message

5.3.4 Visualise module

Live map and alerts. The module exposes a small interface to the rest of the system, which made it possible to develop and test it independently before integration.

- Input: data from the previous stage
- Processing: live map and alerts
- Output: passed to the user
- Errors: logged with a timestamp and shown as a clear message

5.4 Key Code Listings

Listing 1: Measure (ESP32 + LoRa)

```
# Measure stage – PMS5003 and CO2 sensors in each node
def measure_step(record, config):
    """Validate the record, apply the rule and return the result."""
    if not record or record.get("value") is None:
        log.warning("empty record skipped")
        return None
    result = apply_rule(record, config["measure"])
    save(result)          # write to the data store
    return result
```

Listing 2: Transmit (PMS5003)

```
# Transmit stage – LoRa sends readings to a gateway
def transmit_step(record, config):
    """Validate the record, apply the rule and return the result."""
    if not record or record.get("value") is None:
        log.warning("empty record skipped")
        return None
    result = apply_rule(record, config["transmit"])
    save(result)          # write to the data store
    return result
```

Listing 3: Calibrate (InfluxDB)

```
# Calibrate stage – Correction model on the server
def calibrate_step(record, config):
    """Validate the record, apply the rule and return the result."""
```

```
if not record or record.get("value") is None:
    log.warning("empty record skipped")
    return None
result = apply_rule(record, config["calibrate"])
save(result)          # write to the data store
return result
```

Listing 4: Visualise (Leaflet)

```
# Visualise stage – Live map and alerts
def visualise_step(record, config):
    """Validate the record, apply the rule and return the result."""
    if not record or record.get("value") is None:
        log.warning("empty record skipped")
        return None
    result = apply_rule(record, config["visualise"])
    save(result)          # write to the data store
    return result
```

5.5 Challenges Faced

Challenge	How we solved it
Unreliable readings or inputs during early tests	Added validation and averaging before decisions
Integration issues between modules	Agreed a fixed data format and wrote integration tests
Limited time for user testing	Ran short weekly pilots with 5–8 users
Deployment on low-cost hardware	Profiled the code and removed unnecessary libraries

6. Testing and Results

6.1 Testing Strategy

Testing was carried out at three levels: unit testing of individual functions, integration testing of combined modules and acceptance testing with real users. Test cases were derived from the functional requirements, and each requirement was traced to at least one test.

All critical test cases passed in the final round. Minor issues found during user testing, mostly related to labels and error messages, were fixed before the final evaluation.

6.2 Test Cases

ID	Module	Test	Expected result	Status
TC-01	Measure	Valid input	Processed correctly	Pass
TC-02	Measure	Missing / empty input	Skipped with warning	Pass
TC-03	Measure	Boundary value	Handled at threshold	Pass
TC-04	Transmit	Valid input	Processed correctly	Pass
TC-05	Transmit	Missing / empty input	Skipped with warning	Pass
TC-06	Transmit	Boundary value	Handled at threshold	Pass
TC-07	Calibrate	Valid input	Processed correctly	Pass
TC-08	Calibrate	Missing / empty input	Skipped with warning	Pass
TC-09	Calibrate	Boundary value	Handled at threshold	Pass
TC-10	Visualise	Valid input	Processed correctly	Pass
TC-11	Visualise	Missing / empty input	Skipped with warning	Pass
TC-12	Visualise	Boundary value	Handled at threshold	Pass

Table 6.1: Test cases

6.3 Results

The results show that the proposed system meets its objectives. Compared with the existing approach, it is faster, more accurate and easier to use. The figures reported below come from our own test setup and should be treated as indicative rather than definitive.

Users responded positively to the system in the feedback survey. The most appreciated features were the simple interface and the automatic reports, while the most requested improvement was offline support.

Parameter	PM2.5 (µg/m³)	Remark
6 AM	42	Sample value
10 AM	88	Sample value
2 PM	61	Sample value
6 PM	96	Sample value
10 PM	70	Sample value

Table 6.2: Results from the test setup (sample data)

Readings peak with morning and evening traffic, matching the reference station trend.

Key result

0.91 correlation with the reference monitor (sample data from our test setup).

6.4 Outcomes Against Objectives

Objective	Outcome
Build nodes measuring PM2.5, PM10, CO ₂ and humidity	12 nodes deployed
Calibrate against a reference instrument	0.91 correlation after calibration
Publish a live campus air-quality map	1 min update interval
Send alerts when levels cross safe limits	Achieved in the prototype

7. Results and Discussion

This chapter discusses the results in more detail. All figures come from our own test setup over 5 observation periods and are labelled as sample data; replace them with your own measurements.

7.1 Observations by Period

6 AM: PM2.5 ($\mu\text{g}/\text{m}^3$) was 42.
10 AM: PM2.5 ($\mu\text{g}/\text{m}^3$) was 88 — a change of +46 from the previous period.
2 PM: PM2.5 ($\mu\text{g}/\text{m}^3$) was 61 — a change of -27 from the previous period.
6 PM: PM2.5 ($\mu\text{g}/\text{m}^3$) was 96 — a change of +35 from the previous period.
10 PM: PM2.5 ($\mu\text{g}/\text{m}^3$) was 70 — a change of -26 from the previous period.

Insert a line or bar chart of the results here (Insert › Chart in Word)

Figure: PM2.5 ($\mu\text{g}/\text{m}^3$) by period (sample data)

7.2 Comparison with the Existing System

Criterion	Existing system	Proposed system
Aspect 1	Few official stations	Dense low-cost node network
Aspect 2	Hourly, delayed data	Minute-level live map
Aspect 3	No local alerts	Threshold alerts
Headline result	—	0.91 correlation with the reference monitor

7.3 Discussion

Readings peak with morning and evening traffic, matching the reference station trend. The improvement was steady rather than sudden, which suggests that the gains come from the design itself and not from a one-off condition during testing.

Two factors limited the results. First, the pilot ran for a short period with a small group of users, so seasonal or long-term effects are not captured. Second, some inputs were simulated in the laboratory. Both limitations are addressed in the future scope.

7.4 Limitations

- Short pilot period and small sample of users
- Some test conditions simulated in the laboratory
- Prototype hardware and hosting, not production grade
- Results not yet validated by an independent team

8. Project Management

8.1 Team Roles

Member	Roll no.	Responsibilities
Diya Patel	21CS014	Team lead, system design and integration
Kabir Verma	21EC022	Hardware / back-end development and testing

8.2 Schedule (Gantt Chart)

Activity / week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Requirement study	■	■														
Literature survey		■	■	■												
Design				■	■											
Build: Measure					■	■	■									
Build: Transmit							■	■								
Build: Calibrate								■	■	■						
Build: Visualise									■	■	■					
Integration											■	■	■			
Testing													■	■		
Documentation															■	■

Figure: Project schedule — shaded cells are planned weeks (edit by changing cell shading)

8.3 Risk Register

Risk	Likelihood	Impact	Mitigation
Component delivery delayed	Medium	High	Order early; keep a backup supplier
Team member unavailable	Low	Medium	Shared code repository and weekly hand-over notes
Scope creep	Medium	Medium	Freeze requirements after the design review
Data loss	Low	High	Daily backups and version control
Integration failures	Medium	High	Fixed data formats and integration

Risk	Likelihood	Impact	Mitigation
			tests from week 8

8.4 Budget Summary (sample)

Head	Planned (₹)	Actual (₹)	Remark
Hardware / licences	—	—	Replace with your figures
Hosting and tools	—	—	Free tiers used where possible
Printing and documentation	—	—	Report, poster
Contingency	—	—	10% of total

9. Deployment, Maintenance and Impact

9.1 Deployment Plan

5. Prepare the production configuration and secrets file
6. Install dependencies on the target device or server
7. Migrate the database and load the initial master data
8. Run the smoke-test checklist (Appendix A)
9. Train the first group of users and collect feedback after one week

9.2 Maintenance Schedule

Task	Frequency	Responsibility
Check logs and alerts	Daily	Administrator
Back up the database	Daily (automatic)	System
Apply security updates	Monthly	Administrator
Review thresholds and settings	Quarterly	Project owner
Hardware inspection / calibration	Every 6 months	Technician

9.3 Social, Ethical and Environmental Impact

The system benefits its users by saving time and reducing errors, and it makes minute-level live map available to people who could not afford commercial tools. Personal data is limited to what is needed, stored securely and never shared without consent. Where the system automates decisions, a person can always review and override them.

Environmentally, the design favours low-power components and cloud free tiers, and the hardware can be repaired or reused at the end of the project. A short user guide and training session are planned so that the benefits do not depend on the original team.

10. Conclusion and Future Scope

10.1 Conclusion

This project set out to design and build air quality monitoring network and has achieved that goal with a working prototype. The system demonstrates that a low-cost, well-structured solution can make a measurable difference to everyday processes.

The experience also gave the team practical exposure to requirement analysis, system design, teamwork and documentation – skills that will be valuable in professional practice.

- Low-cost nodes give useful, local air-quality data
- Calibration is essential for accuracy
- A live map raises awareness quickly

10.2 Future Scope

- City scale — Expand to nearby wards
- Forecasting — Predict next-day AQI
- Health alerts — Notify sensitive groups

11. References

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12. Appendix A: User Manual

A.1 Installation

Install the required software listed in Table 3.3 and copy the project folder to the computer or device.

- Step 1: prepare the computer
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

A.2 First run

Open the application, create the administrator account and set the basic configuration values.

- Step 1: prepare the computer
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

A.3 Measure

PMS5003 and CO₂ sensors in each node. Open the measure screen, check the status indicator and follow the prompts.

- Step 1: open the module from the main menu
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

A.4 Transmit

LoRa sends readings to a gateway. Open the transmit screen, check the status indicator and follow the prompts.

- Step 1: open the module from the main menu
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

A.5 Calibrate

Correction model on the server. Open the calibrate screen, check the status indicator and follow the prompts.

- Step 1: open the module from the main menu
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

A.6 Visualise

Live map and alerts. Open the visualise screen, check the status indicator and follow the prompts.

- Step 1: open the module from the main menu
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

A.7 Reports

Choose a date range on the reports screen and export as CSV or PDF.

- Step 1: open the module from the main menu
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

A.8 Troubleshooting

If a module shows an error, check the connection and the log file, then restart that module only.

- Step 1: open the module from the main menu
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

13. Appendix B: Project Diary

Weekly record of work, reviewed and signed by the project guide.

Week	Phase	Work done	Guide sign
Week 1	Requirement study	Literature survey and user questionnaire	
Week 2	Requirement study	Literature survey and user questionnaire	
Week 3	Design	Architecture and data design	
Week 4	Design	Architecture and data design	
Week 5	Development – Measure	PMS5003 and CO ₂ sensors in each node	
Week 6	Development – Measure	PMS5003 and CO ₂ sensors in each node	
Week 7	Development – Transmit	LoRa sends readings to a gateway	
Week 8	Development – Transmit	LoRa sends readings to a gateway	
Week 9	Development – Calibrate	Correction model on the server	
Week 10	Development – Calibrate	Correction model on the server	
Week 11	Development – Visualise	Live map and alerts	
Week 12	Development – Visualise	Live map and alerts	
Week 13	Integration	Combined modules and fixed interface issues	
Week 14	Integration	Combined modules and fixed interface issues	
Week 15	Testing	Executed test cases and user pilot	
Week 16	Testing	Executed test cases and user pilot	

Week	Phase	Work done	Guide sign
Week 17	Documentation	Report writing and presentation	
Week 18	Documentation	Report writing and presentation	
Week 19	Requirement study	Literature survey and user questionnaire	
Week 20	Requirement study	Literature survey and user questionnaire	
Week 21	Design	Architecture and data design	
Week 22	Design	Architecture and data design	
Week 23	Development – Measure	PMS5003 and CO ₂ sensors in each node	
Week 24	Development – Measure	PMS5003 and CO ₂ sensors in each node	

14. Appendix C: Glossary

Term	Meaning
ESP32 + LoRa	Node controller and radio
PMS5003	Particulate matter sensor
InfluxDB	Time-series storage
Leaflet	Interactive map
Measure stage	PMS5003 and CO ₂ sensors in each node
Transmit stage	LoRa sends readings to a gateway
Calibrate stage	Correction model on the server
Visualise stage	Live map and alerts
Prototype	A working early version built to test the idea
Pilot	A small trial with real users before wider use

15. Appendix D: Detailed Test Logs

Measure module

Date	Case	Condition	Observed	Status
03/11/2025	Case 1	Normal value	As expected	Pass
06/11/2025	Case 2	Minimum value	As expected	Pass
09/11/2025	Case 3	Maximum value	As expected	Pass
12/11/2025	Case 4	Empty input	Handled with message	Pass
15/11/2025	Case 5	Repeated input	As expected	Pass
18/11/2025	Case 6	Invalid format	Handled with message	Pass
21/11/2025	Case 7	Network off	As expected	Pass
24/11/2025	Case 8	Power cycle	As expected	Pass

Transmit module

Date	Case	Condition	Observed	Status
03/11/2025	Case 1	Normal value	As expected	Pass
06/11/2025	Case 2	Minimum value	As expected	Pass
09/11/2025	Case 3	Maximum value	As expected	Pass
12/11/2025	Case 4	Empty input	Handled with message	Pass
15/11/2025	Case 5	Repeated input	As expected	Pass
18/11/2025	Case 6	Invalid format	Handled with message	Pass
21/11/2025	Case 7	Network off	As expected	Pass
24/11/2025	Case 8	Power cycle	As expected	Pass

Calibrate module

Date	Case	Condition	Observed	Status
03/11/2025	Case 1	Normal value	As expected	Pass
06/11/2025	Case 2	Minimum value	As expected	Pass
09/11/2025	Case 3	Maximum value	As expected	Pass

Date	Case	Condition	Observed	Status
12/11/2025	Case 4	Empty input	Handled with message	Pass
15/11/2025	Case 5	Repeated input	As expected	Pass
18/11/2025	Case 6	Invalid format	Handled with message	Pass
21/11/2025	Case 7	Network off	As expected	Pass
24/11/2025	Case 8	Power cycle	As expected	Pass

Visualise module

Date	Case	Condition	Observed	Status
03/11/2025	Case 1	Normal value	As expected	Pass
06/11/2025	Case 2	Minimum value	As expected	Pass
09/11/2025	Case 3	Maximum value	As expected	Pass
12/11/2025	Case 4	Empty input	Handled with message	Pass
15/11/2025	Case 5	Repeated input	As expected	Pass
18/11/2025	Case 6	Invalid format	Handled with message	Pass
21/11/2025	Case 7	Network off	As expected	Pass
24/11/2025	Case 8	Power cycle	As expected	Pass

16. Appendix E: Survey Questionnaire

Questionnaire (sample)

How often do you perform this task?

How long does it take today?

What is the most frustrating part?

Which device do you use most?

Would you use an automated system? Why or why not?

Which reports or alerts would help you most?

How much would you be willing to spend, if anything?

Any other suggestions?

17. Appendix F: Survey Responses (sample data)

Question	Strongly agree	Agree	Neutral	Disagree
The current process takes too long	—	—	—	—
Errors are common today	—	—	—	—
I would use a mobile app	—	—	—	—
Alerts would be useful	—	—	—	—
Reports would help decisions	—	—	—	—
I can learn a new tool quickly	—	—	—	—

Replace the dashes with your own survey counts.