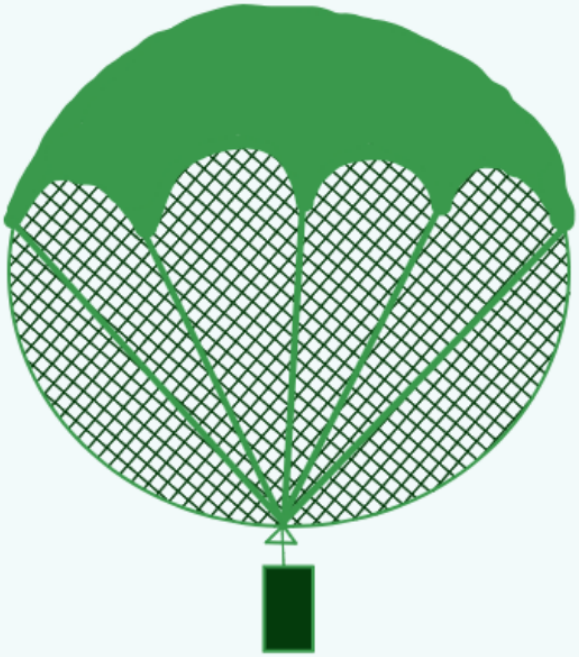
Mahaveer Public School

WEATHER PREDICTION SYSTEM

Accurate Forecasting through Sensor Data & Machine Learning



By Arihant Jain

Introduction

When we see weather forecasts, we often wonder: How are these predictions made? The Indian Meteorological Department (IMD) is responsible for creating these forecasts by gathering large amounts of data. One of the primary sources of this data is *High Altitude Data Collectors (HADCs)*.

HADCs are devices equipped with sensors and attached to balloons that are released into the atmosphere. These sensors collect data at various altitudes, helping meteorologists understand weather patterns at different heights. However, there is a challenge with this system. As the balloon rises to higher altitudes, the pressure decreases, causing the balloon to burst. When this happens, the attached sensors fall to the ground and are often damaged beyond repair, making the devices unusable for future launches.

To overcome this issue, we propose integrating a **parachute system** into the HADC design. Once the balloon bursts, the parachute will deploy, allowing the sensors to descend safely to the ground without being damaged. This solution offers two major benefits:

- **Reuse**: The devices can be reused for multiple missions, reducing waste and cutting down on equipment costs.
- **Reduce**: By minimizing the need for new equipment and reducing damage, we can lower the overall costs of weather data collection and make the process more efficient.

Our approach will help gather more data with greater accuracy, leading to better weather predictions.

Empathize

The need for improved weather prediction at a local scale emphasizes our project's purpose. Traditional methods often lack the precision required for localized forecasts, affecting agriculture, daily planning, and disaster response. By interacting with and gathering insights from various sectors that rely on weather data, we aim to create an efficient, cost-effective, real-time forecasting system. Users have expressed the need for more accurate, short-term predictions to make informed decisions, particularly in time-sensitive areas such as farming and emergency management.

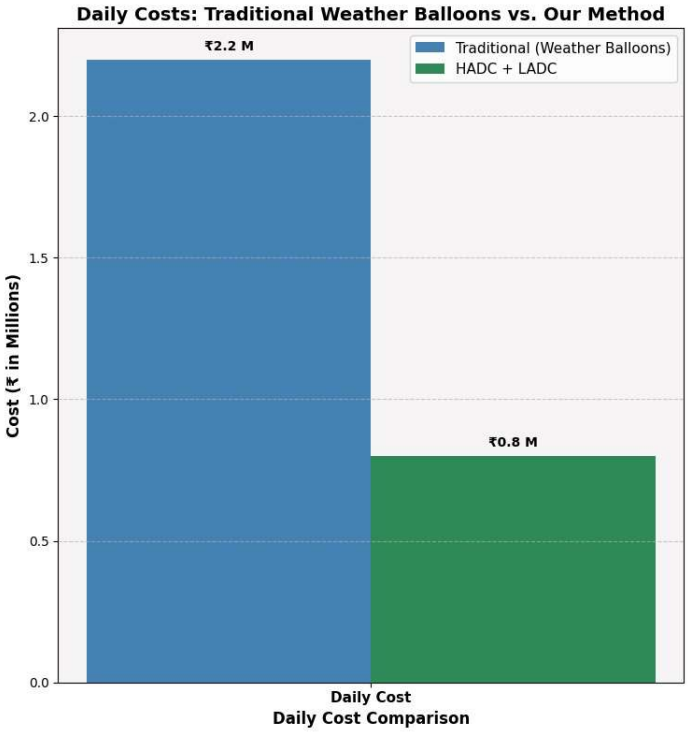
High Altitude Data Collectors (HADCs) are balloon-equipped systems used to gather weather data at various altitudes. A key challenge is that the balloons burst at high altitudes due to low pressure, causing the sensors to fall and often get damaged, making them unusable for future missions. This increases costs and limits reusability, underscoring the need for innovation in data collection.

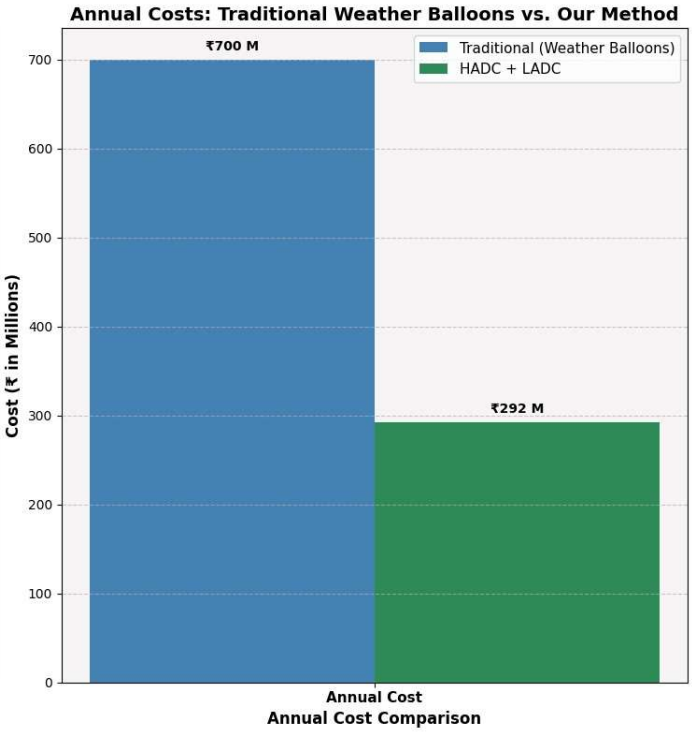
Define

The problem is clear: existing weather prediction systems struggle to provide highly localized, accurate short-term forecasts, which impacts decision-making across sectors like agriculture, disaster management, and other fields. Our goal is to integrate sensor data with machine learning algorithms to create a more precise, real-time weather forecasting tool that provides users with actionable, data-driven insights for better short-term planning.

This goal will be achieved by collecting more data from **High Altitude Data Collectors (HADC)** and **Low Altitude Data Collectors (LADC)**, and by reducing data collection costs.

Traditional HADCs face a significant problem: when weather balloons carrying these devices reach a certain altitude, they burst due to the decreasing atmospheric pressure. Upon bursting, the device containing sensors falls to the ground and often sustains damage, rendering it unusable for future missions. This results in increased costs and wasted resources.





Our project can reduce costs by approximately ₹2 Million daily and ₹400 Million annually.

Ideate

Key scientific and data concepts structure our approach, including:

- **Meteorology** for analyzing weather patterns.
- **Data Science** for predicting weather conditions.
- **GUI Design** for an intuitive user experience, tailored for professionals to easily interpret data.

For materials, we use:

- **Sensors** for detecting temperature, humidity, and rain.
- **Data Analysis Tools**: Python libraries like PyQt5 (for GUI), Matplotlib (for visualization), Pandas (for data management), and Scikit-learn (for machine learning).

Highlights of Our Devices:

- *High Altitude Data Collectors (HADCs)*: Adding a parachute system to weather balloons prevents equipment damage upon descent, reducing costs and ensuring reliable data collection.
- *Low Altitude Data Collectors (LADCs)*: Installing LADCs on rooftops provides stable, localized data capture at lower altitudes, enhancing short-term weather insights.

Prototype

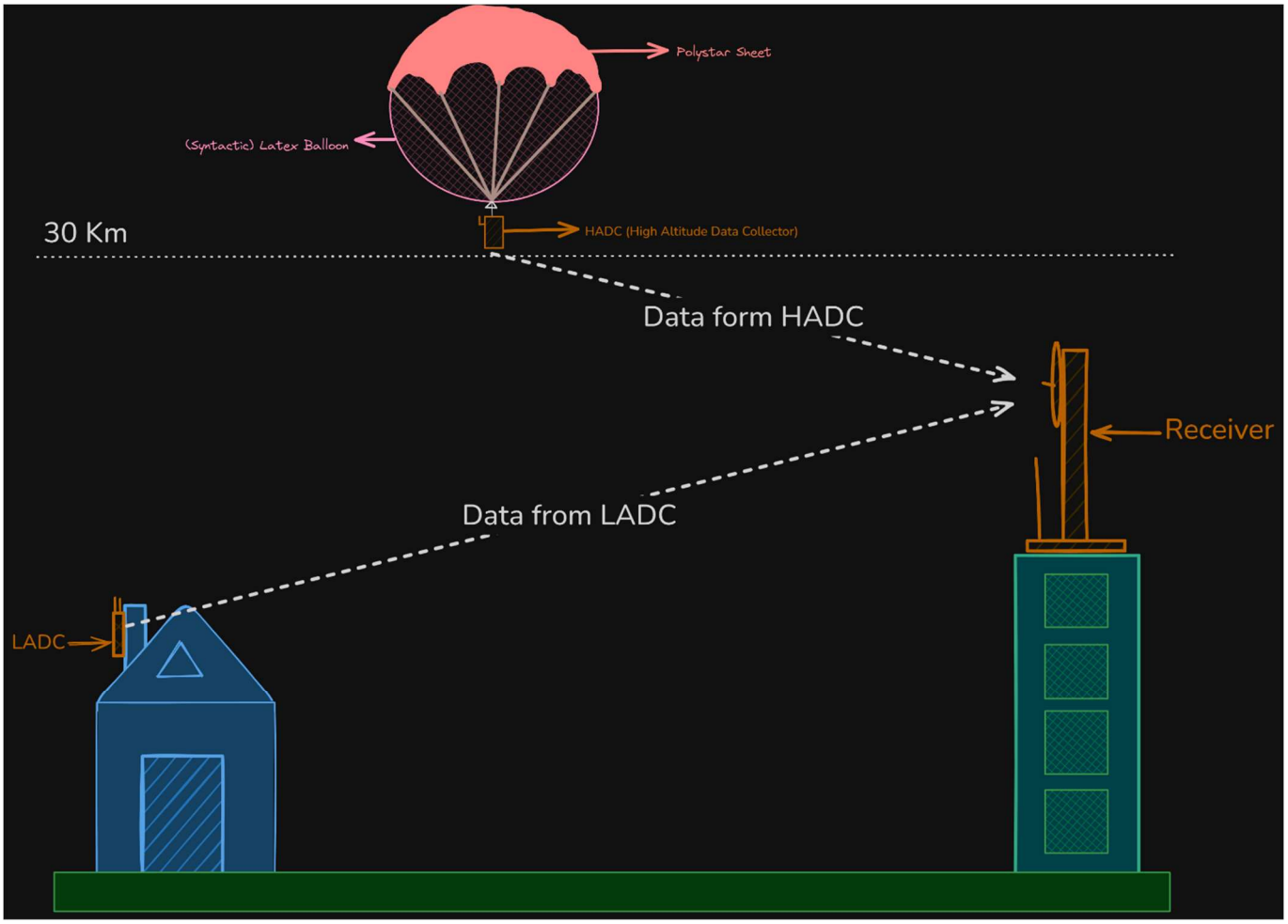
Workflow of our Project

In this phase, we develop and integrate each system component:

1. **Sensor Setup**: Connect and calibrate temperature, humidity, and rain sensors to an Arduino.
2. **Data Collection**: Collect and store real-time data in a CSV file for easy access and management.
3. **Machine Learning Model**: Use Scikit-learn to analyze historical data and predict weather patterns based on variables like temperature, humidity, and precipitation.
4. **GUI Development**: Create a user interface using PyQt5 for straightforward data visualization and interaction.
5. **Data Visualization**: Implement Matplotlib to display trends in temperature, humidity, and precipitation on the GUI.

Expansion Achieved: The integration of HADCs with parachutes and LADCs on rooftops has already been completed, improving data collection accuracy across various altitudes for more refined predictive capabilities.

Future Vision: Moving forward, we aim to further enhance the sustainability of our devices by making them biodegradable and lightweight. This will not only contribute to reducing environmental impact but also improve the cost-effectiveness and efficiency of our weather prediction system.



Test

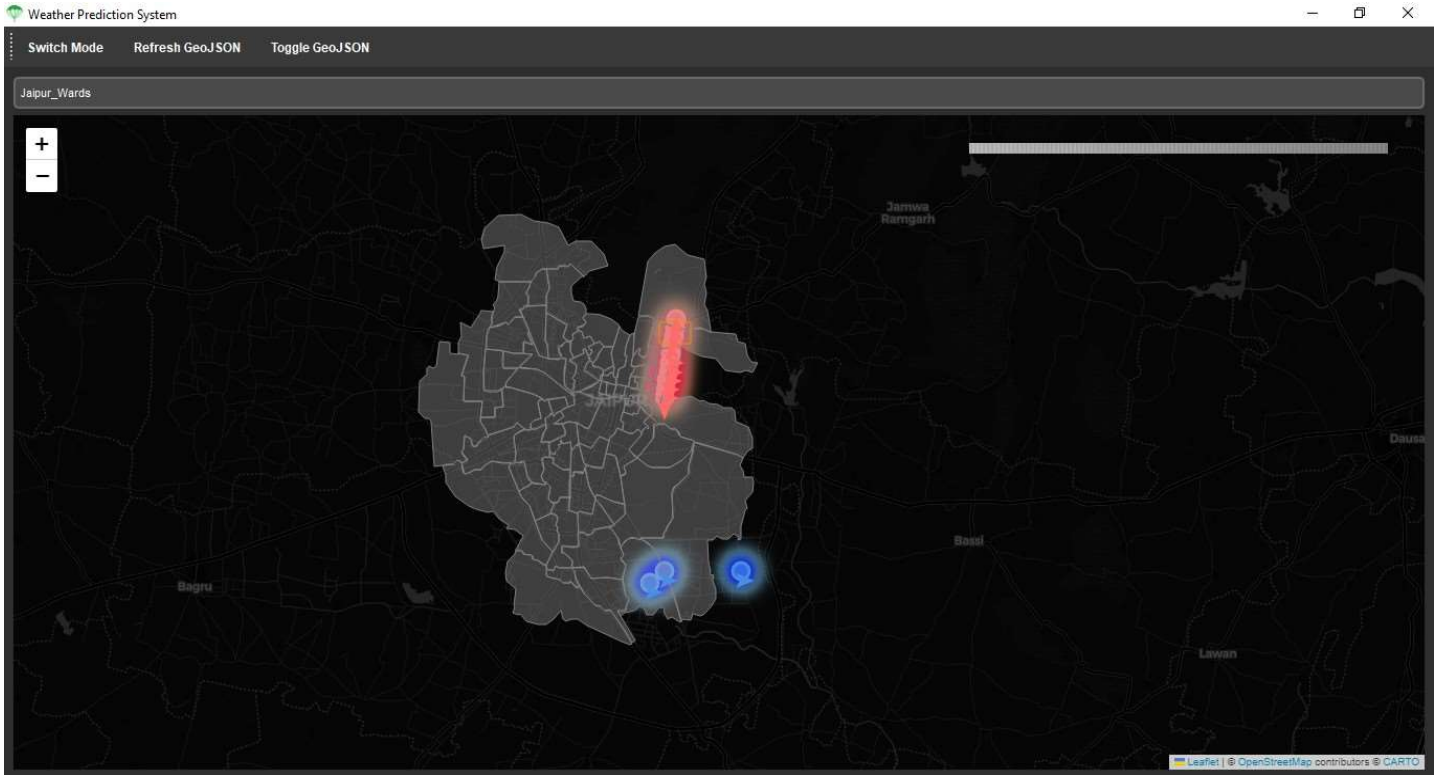
Testing is conducted at each stage:

1. **Sensor Accuracy**: Verify that sensors produce reliable data under different environmental conditions.
2. **Model Performance**: Test machine learning models by comparing predictions with actual data and refining the algorithm for better accuracy.
3. **Feedback on GUI**: Collect feedback on GUI usability, making adjustments to improve the user experience.

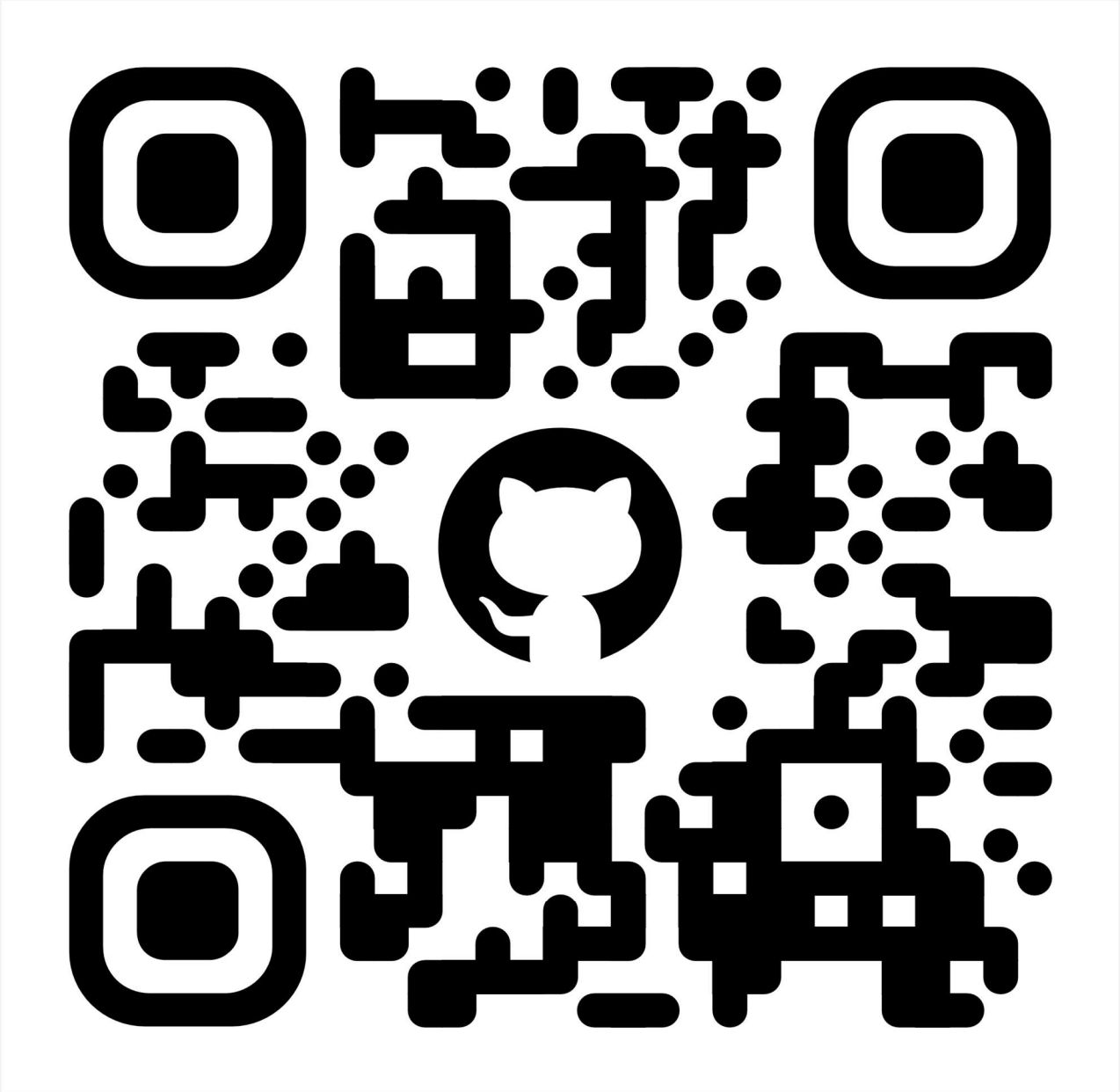
Future Testing: After integrating HADCs and LADCs, additional testing will ensure the reliability of high and low-altitude data collection, analyzing how these innovations complement our main system.

App Preview:


Line Graph Data Visualization
Line Graph Data Visualization
Select File:
data/raw/HADC\location_1.csv
Toggle Theme
Start Real-time
location_1.csv
Temperature
Humidity
AQI
Values
70
60
50
40
30
20
10
23 21:15
23 21:20
23 21:25
Time


Weather Prediction System
Switch Mode
Refresh GeoJSON
Toggle GeoJSON
Jaipur_Wards
Jamwa Ramgarh
Bagru
Bassi
Lawan
Leaflet | © OpenStreetMap contributors © CARTO

Code Provided



The complete app code for our *Weather Prediction System* is available on GitHub. Scan the QR code above to access the repository.

You can explore the code, which includes features like:

- Weather and wind data visualization using *Folium*.
- Integration of *GeoJSON* overlays and heatmaps for dynamic mapping.
- A user-friendly interface with light/dark mode options.
- Interactive map elements for enhanced user experience.

Visit the repository here: Weather Prediction System on GitHub or scan this QR Code.

Implement

Upon successful testing, we deploy the system and continuously monitor its Upon successful testing, we deploy the system and continuously monitor its performance. Users can access real-time data and predictions, improving their ability to make short-term decisions based on accurate weather information.

The integration *of* ***High Altitude Data Collectors (HADCs)*** **with parachutes** has already been achieved. This ensures that after the weather balloons burst at high altitudes, the attached devices descend safely, preserving the equipment for future use. This advancement not only reduces costs associated with equipment loss but also improves the reliability of data collection across different altitudes.

Future Implementation: To expand our system's impact, we plan to deploy permanent **Low Altitude Data Collectors (LADCs)** in selected locations. Integrating these devices into our weather prediction system will provide more comprehensive insights, leading to a robust forecasting model that leverages both high and low-altitude data sources for enhanced accuracy.

Expected Outcomes

By following these stages, we aim to create a robust, low-cost weather prediction system with the following benefits:

- Improved reliability of high and low-altitude data.
- Enhanced short-term weather forecasts based on comprehensive, localized data.
- Reduced costs due to minimized equipment damage at high altitudes.

References

Our project was inspired and informed by the following sources:

- **Teachers:** Our dedicated educators provided invaluable guidance and knowledge, especially on the integration of weather sensors and the fundamentals of machine learning for accurate forecasting.
- **Websites:** Extensive research on reputable websites and scientific AI literature helped us better understand machine learning algorithms, weather prediction techniques, and sustainable data collection methods.
- **Documentation:** We relied on official documentation for Python libraries such as *Pandas*, *Matplotlib*, *Folium*, and *PyQt5* for data handling, visualization, and building the user interface.
- **Blogs and Articles:** Various online blogs and articles provided insights into recent advancements in weather forecasting technology, the use of sensors for environmental data collection, and the importance of sustainable practices in meteorology.