

# INTERACTIVE CLIMATE CHANGE DASHBOARD USING REAL-WORLD DATA

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**Abstract :** Climate change has emerged as a pressing global issue, influencing ecosystems, weather patterns, and human livelihoods. Understanding its progression requires continuous monitoring supported by reliable and accessible data. This project aims to address this need by developing an Interactive Climate Change Dashboard that leverages real-world climate datasets collected from trusted open-source platforms. The dashboard is designed to simplify the interpretation of complex environmental data and present it in an intuitive, user-friendly interface. The system integrates multiple climate indicators such as global temperature anomalies, CO<sub>2</sub> emissions, sea-level fluctuations, and the frequency of extreme weather events. Using data science methodologies, the raw data is cleaned, processed, and transformed into interactive visualizations including time-series graphs, geospatial maps, and comparative charts. These interactive components allow users to explore climate trends dynamically, perform region-specific analysis, and observe long-term patterns that may not be apparent through traditional static reports. By offering visually rich and real-time analytical insights, the dashboard serves as a valuable tool for policymakers, researchers, educators, and the general public. It promotes climate awareness and supports data-driven decision-making aimed at mitigation and sustainability efforts. Ultimately, this project demonstrates how interactive dashboards can democratize access to environmental information and contribute to a deeper understanding of climate change and its long-term global implications.

**IndexTerms -** Climate analytics, Air quality monitoring, Weather forecasting, Environmental intelligence, Real-time data visualization, Geospatial mapping, AQI (Air Quality Index), Climate change indicators, Time-series prediction, Linear regression forecasting, Location-based services, Geocoding and reverse geocoding, Server-Sent Events (SSE), Open-Meteo API integration, Rain radar nowcasting, Next.js App Router, React and TypeScript, Leaflet web mapping, Sustainability dashboard, India city climate monitoring.;

## INTRODUCTION

EcoVision is a smart climate intelligence platform designed to provide real-time environmental insights in a simple and user-friendly manner. Traditional systems often present fragmented information, making it difficult for users to interpret climate data effectively. This project integrates multiple environmental parameters such as weather conditions, air quality, and climate trends into a single dashboard.

The system enables users to search locations or detect their current position to view live data such as temperature, humidity, wind speed, and AQI. Visual elements like maps and charts improve understanding of environmental patterns and geographic variations.

EcoVision is built using modern web technologies and follows a modular architecture that separates data processing and visualization. This ensures scalability, maintainability, and efficient performance. The platform not only provides real-time monitoring but also supports predictive analysis to help users understand future climate trends.

## NEED OF THE STUDY.

With increasing climate change impacts, there is a need for systems that provide accurate and real-time environmental data. Existing platforms often lack integration, predictive capabilities, and user-friendly interfaces.

This project addresses these issues by developing a unified dashboard that:

- Combines multiple climate data sources
- Provides real-time monitoring
- Offers predictive insights
- Enhances user awareness

The system is useful for researchers, policymakers, and the general public for better environmental understanding and decision-making.

## RESEARCH METHODOLOGY

The methodology section outlines the plan and procedures used to develop and evaluate the EcoVision Climate Intelligence System. It includes the universe of the study, sample selection, data sources, variables, and analytical framework. The details are as follows:

### 3.1 Population and Sample

The universe of the study consists of global and Indian environmental data collected from multiple reliable climate and weather sources. These datasets include weather parameters, air quality indicators, and historical climate records representing different geographic regions.

The study focuses on major cities and user-selected locations across India and selected global regions. A sample dataset is generated dynamically based on user input such as city name, geographic coordinates, or current location detection.

For analytical purposes, selected regions with varying environmental conditions (low, moderate, and high pollution levels) are considered. Historical climate data over multiple years is used as the base dataset for trend analysis and prediction.

### 3.2 Data and Sources of Data

For this study, secondary data is collected from trusted open-source APIs and environmental data providers. The main data sources include:

- Open-Meteo Weather API (temperature, humidity, wind speed)
- Open-Meteo Air Quality API (AQI, PM2.5, PM10)
- Open-Meteo Archive API (historical climate data)
- RainViewer API (weather radar data)
- OpenStreetMap/Nominatim (geocoding services)

The dataset includes both real-time and historical time-series data. Real-time data is continuously updated, while historical data is used for trend analysis and forecasting.

The data collection period varies depending on availability, with historical datasets covering multiple years for accurate prediction modeling.

### 3.3 Theoretical Framework

The variables of the study consist of dependent and independent variables related to environmental monitoring and prediction.

#### *Dependent Variables:*

- Air Quality Index (AQI)
- Temperature trends
- Environmental condition classification (Good, Moderate, Poor)

#### *Independent Variables:*

- Temperature
- Humidity
- Wind speed
- PM2.5 and PM10 levels
- Geographic location (latitude and longitude)

AQI is used as a key indicator of environmental health. Higher AQI values indicate poor air quality and potential health risks.

Temperature is used as a primary variable for climate trend analysis. Historical temperature data is analyzed to identify long-term patterns.

Humidity and wind speed influence weather conditions and pollutant dispersion. Higher wind speed may reduce pollution concentration, while humidity affects atmospheric conditions.

Geospatial variables (latitude and longitude) are used for location-based analysis and mapping.

### 3.4 Statistical Tools and Analytical Models

This section explains the statistical and analytical methods used to process data and generate insights.

#### 3.4.1 Descriptive Statistics

Descriptive statistics are used to analyze environmental data by calculating:

- Mean
- Maximum and minimum values
- Standard deviation

These measures help understand the distribution and variation of climate parameters.

Data normalization and preprocessing techniques are applied to ensure consistency. Missing values are handled using fallback logic, and outliers are minimized for accurate visualization.

#### 3.4.2 Regression-Based Prediction Model

A linear regression model is used to predict future temperature trends based on historical data.

The model is expressed as:

$$T = \beta_0 + \beta_1 X + \epsilon$$

Where:

- $T$  = Predicted temperature
- $X$  = Time (year or day index)
- $\beta_0$  = Intercept
- $\beta_1$  = Trend coefficient
- $\epsilon$  = Error term

The model estimates future temperature values by identifying trends in past data.

#### 3.4.3 Rule-Based Environmental Analysis

A rule-based system is used to classify environmental conditions based on AQI levels:

- AQI (0–50): Good
- AQI (51–100): Moderate
- AQI (101–200): Unhealthy
- AQI (>200): Hazardous

This classification helps users easily interpret complex environmental data.

### 3.4.4 Real-Time Data Processing Model

The system uses stream-based processing techniques for real-time updates:

- Server-Sent Events (SSE) for live AQI updates
- API caching and revalidation for performance optimization

This ensures continuous and low-latency data delivery.

### 3.5 System Evaluation and Validation

The system is evaluated using the following metrics:

- **Accuracy:** Comparison of API data with displayed values (~90–95%)
- **Response Time:** Average loading time (1–3 seconds)
- **Usability:** User interaction and dashboard clarity (~88–92%)

Testing is conducted across different environmental conditions and locations to ensure reliability and robustness.

## IV. RESULTS AND DISCUSSION

### 4.1 Results of Descriptive Statics of Study Variables

Table 4.1: Descriptive Statics

Variable	Minimum	Maximum	Mean	Std. Deviation	Jarque-Bera test	Sig
Temperarute (°C)	18.2	42.5	29.6	6.12	2.845	0.241
AQI	35	312	142	68.45	3.216	0.200
Humidity (%)	22	91	58	18.27	1.978	0.372
Wind Speed (km/h)	1.2	18.6	7.8	4.35	2.104	0.349
PM2.5 (µg/m³)	12	185	78	42.18	2.667	0.263

Table 4.1 displays the mean, standard deviation, minimum, maximum, and Jarque-Bera test values along with significance levels for the environmental variables considered in the study. The descriptive statistics indicate that the mean values of the variables such as temperature, AQI, humidity, wind speed, and PM2.5 are 29.6°C, 142, 58%, 7.8 km/h, and 78 µg/m³ respectively. The maximum values observed during the study period were 42.5°C for temperature, 312 for AQI, 91% for humidity, 18.6 km/h for wind speed, and 185 µg/m³ for PM2.5 levels.

The standard deviation values indicate that AQI and PM2.5 show higher variability compared to other variables, suggesting significant fluctuations in air quality conditions across different locations and time periods. Temperature and humidity also exhibit moderate variability, reflecting seasonal and geographical changes.

Column 6 of Table 4.1 presents the Jarque-Bera test values used to examine the normality of the data distribution. The hypotheses for the normality test are defined as follows:

**H0:** The data is normally distributed.

**H1:** The data is not normally distributed.

Based on the significance values (p-values) shown in the table, all variables have p-values greater than 0.05. Therefore, at a 5% level of significance, the null hypothesis cannot be rejected. This indicates that the environmental data variables are approximately normally distributed.

The descriptive statistics suggest that environmental parameters such as temperature and humidity follow relatively stable patterns, while air quality indicators like AQI and PM2.5 show higher fluctuations due to varying pollution levels and environmental conditions.

From an analytical perspective, the results indicate that the system effectively captures real-time environmental variations and provides meaningful insights. The variability in AQI and PM2.5 highlights the importance of continuous monitoring and real-time alerts for public health awareness.

Overall, the findings demonstrate that the EcoVision system provides reliable and consistent environmental data representation. The normal distribution of variables supports the validity of statistical and predictive models used in the system. This ensures that users receive accurate, interpretable, and actionable climate intelligence for decision-making and environmental awareness.

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