Software Requirement Specifications

Plantree AI

Version: [1.0]

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Version	Sign-off Authority	Sign-off Date

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1. Introduction

1.1. Purpose of Document

The purpose of this document is to provide a comprehensive Software Requirements Specification (SRS) for the project titled "Plantree: An AI-Enhanced Regional Tree Plantation Predictor to Minimize Climate Impact." This document outlines the functional and non-functional requirements, system features, and other critical elements necessary to design and develop the project. By presenting detailed specifications, this document ensures that all stakeholders, including project sponsors, developers, and users, have a unified understanding of the project's scope and objectives. The primary goal of this project is to optimize tree plantation locations by utilizing AI and IoT technologies to combat climate change effectively and sustainably.

1.2. Intended Audience

This document is intended for the following audience:

- **Environmental Organizations**: Organizations like Billion Tree Tsunami and MTJ Tree Plantation, which actively run tree plantation campaigns, can use this document to understand the solution's functionality and applicability.
- **Project Developers and Designers**: Software engineers, AI specialists, and IoT experts working on this project will use this document as a blueprint to guide development.
- **Academic Supervisors and Evaluators**: Faculty members and university examiners responsible for evaluating the project will refer to this document to assess the scope, feasibility, and completeness of the solution.
- **Government Agencies**: Entities working on environmental sustainability initiatives can leverage this project as a reference for implementing large-scale tree plantation campaigns.

This document serves as a guide for anyone involved in understanding, developing, or supporting the system, ensuring clarity in project objectives and deliverables.

1.3. Abbreviations

The following abbreviations are used throughout this document:

- **AI**: Artificial Intelligence
- **IoT**: Internet of Things
- **ESP32**: A microcontroller with integrated Wi-Fi and Bluetooth capabilities
- **DHT11**: A digital sensor for measuring temperature and humidity
- **MQ135:** A digital sensor to observe Air Quality of the specific location
- **1D CNNs:** 1D Convolutional Neural Networks
- **SVM:** Support Vector Machine
- **MTJ**: Maulana Tariq Jameel (reference to MTJ Tree Plantation)
- **PTI**: Pakistan Tehreek-e-Insaf (organization running Billion Tree Tsunami)

These abbreviations are used to simplify technical terminologies and improve readability throughout the document.

1.4 Document Convention

To ensure clarity, consistency, and a professional presentation, the following conventions are adhered to in this document:

- **Font Style**: The document uses Times New Roman for all text content.
- **Font Size**:
  - Main headings: **18pt, Bold**
  - Subheadings: **16pt, Bold**
  - Body text: **14pt, Regular**
  - Footnotes and references: **14pt, Italic**
- **Line Spacing**: All text is written with **1.15 line spacing** for better readability.
- **Alignment**:
  - Headings: **Left-aligned**
  - Paragraphs: **Justified**
- **Document Structure**: Each section begins with a heading, followed by subheadings, and uses numbered or bulleted lists wherever necessary to organize information.
- **Formatting Highlights**:
  - Keywords or technical terms are highlighted in **bold** or italic for emphasis.
  - Hyperlinks, if included, are presented in blue and underlined for easy identification.

This formatting ensures a professional appearance, making the document easy to navigate and comprehend for all readers.

2. Overall System Description

2.1. Project Background

Since the topic of global warming and climate change has received a lot of concern in recent years, governments, organizations, and individuals have looked for best ways of minimizing their influence towards the environment. Among such solutions is large-scale tree plantation, a well-known method for reduction of increasing carbon emissions and enhancing the quality of air. Nevertheless, tree plantation campaigns, in most of the cases, do not receive their deserved outcomes because of insufficient application of adequate methods.

Today, tree plantation programs are undertaken based on assumed average factors such as temperatures, humidity and quality of air not knowing that these factors vary from one region of the country to another and are so influential in the growth of trees. This inefficiency results in low tree survival rates, wastage of resources and capability to conquer climate effects.

To these challenges, we are currently working on “Plantree”, an AI enhanced regional tree plantation predictor that would enhance the success of tree plantation campaigns. It uses IoT Sensors like ESP32, MQ135, DHT 11 and AI pre-trained models like SvM, Random Forest, Neural Network and 1D CNN to enhance environment inputs and predict the regions best to plant trees. In giving efficient advice, Plantree promotes the effective utilization of resources, high survival rate of trees, and a quantifiable increase in combating climate change effects.

2.2. Project Scope

The scope of the Plantree project encompasses the design, development, and deployment of a system capable of::

- Using environment IoT sensors to gather data including temperature, humidity and air quality in the environment.
- Then using artificial intelligence models to analyze the collected data for the best regions for tree plantation.
- Estimating possible effects of plantations in future environmental terms, such as sequestration of carbon dioxide and amelioration of local climate.
- Also, developing a convenient interface for organizations: to get advice, to track the progress of plantations and to create the reports.
- Providing solutions according to the goals of particular promotional campaigns or non-profit organizations.

Boundaries and Functionalities:

- The system will focus on collecting real-time data within a specified region, ensuring accurate and location-specific recommendations.
- It will analyze data and provide insights for regions that can sustain specific tree species based on environmental conditions.
- The system will not include physical plantation activities but will act as a decision-making tool for stakeholders.
- The solution will be adaptable for integration into existing tree plantation workflows of organizations.

2.3. Not In Scope

The following functionalities are explicitly out of scope for the current version of Plantree:

- Actual implementation of tree plantation activities.
- Periodic assessment of the growth or healthy status of planted trees probably after a period the expert provided the recommendation.
- Building up connections with other governmental or international climate data bases in addition to the basic needs of the system.
- Forecasting of the tangible monetary returns of plantation campaigns.
- Maintenance and support of regions apart from the primary stakeholders' areas of deployment.

2.4. Project Objectives

The primary objective of the *Plantree* project is to revolutionize tree plantation campaigns by integrating data-driven decision-making processes. Specifically, the project aims to:

- **Optimize Plantation Campaigns**: Use AI to recommend the most suitable regions for planting trees, ensuring higher survival rates and maximum environmental benefits.
- **Enhance Resource Utilization**: Reduce the wastage of resources by targeting plantations in regions with favorable environmental conditions.
- **Support Climate Goals**: Contribute to global and regional efforts to mitigate climate change through effective tree plantation.
- **Enable Predictive Insights**: Provide predictions on the long-term impact of plantations, such as carbon absorption rates and improved air quality.

- **Simplify Decision-Making**: Offer a user-friendly platform for stakeholders to make informed decisions with ease.

The end result of the project will be a robust system that empowers organizations to achieve their plantation goals with greater efficiency and measurable outcomes.

2.5. Stakeholders

The Plantree system is designed for a wide range of stakeholders who will interact with the system in different capacities:

Primary Stakeholders:

- The Billion Tree Tsunami and MTJ Tree Plantation are environmental organizations and foundations that can be of help.
- International and local nonprofit organizations for sustainability, reforestation, environmental conservation and enhancement purposes.
- County and regional departments involved in environmental protection measures.

Secondary Stakeholders:

- IT specialists who create and maintain AI-embedded systems, AI analysts, data miners, and other specialists whose professional activity implies work with AI systems.
- Software developers working with IoT compartments such as ESP32, MQ135 and DHT11 as terminal tools.
- Project stakeholders such as planners, schedulers, project implementers and coordinators of campaigns to use the software in planning and supervising plantation activities.

2.6. Operating Environment

The Plantree system will operate in the following environment:

Hardware Platform:

- IoT sensors such as ESP32 for network communication, MQ135 for observing air quality and DHT11 for capturing temperature and humidity data.
- Cloud-based servers for data storage, processing, and AI model deployment.

Operating System:

- The system will be compatible with Windows, Linux, and macOS for development and testing.
- IoT devices will operate on firmware designed for ESP32-compatible environments.

Network Environment:

- Requires a stable internet connection for IoT devices to transmit real-time data to the cloud.
- Secure network protocols will ensure the privacy and integrity of data.

Software Components:

- AI models like SvM, Random Forest, Neural Network and 1D CNN for predictive analytics.
- Web-based user interface built using modern frameworks like React or Angular.

2.7. System Constraints

The following constraints are imposed on the system:

Software Constraints:

- The AI models have to analyze large or complex data within a specific period to be able to make prompt recommendations.
- The graphical user interface I still have to keep as simple for the non-technical persons that are in one way or the other going to use it.

Hardware Constraints:

- Precision sensors integrated into IoT need consistent power supply and connectivity to deliver their best.
- The various hardware parts required must be able to withstand different environmental climates.

Cultural Constraints:

- The system must also be pal and equipped to take into account the fact that many of the users are likely to be from different parts of the world and as such, are more likely than not, to be conversant in a number of languages.

Legal Constraints:

- Data privacy laws and environmental regulations have to be followed.
- The system has to embrace the principles of secure management of sensitive environmental data.

Environmental Constraints:

- IoT sensors may come across problems in weather vagaries, for example, high humidity, or harsh climates.

User Constraints:

- This is because the interface has to be developed such that all the users who will be accessing it have sufficient computer literacy.

2.8. Assumptions & Dependencies

The development and deployment of Plantree are based on the following assumptions and dependencies:

Assumptions:

- The IoT sensors will provide the accurate and optimum environmental data to the user.
- Users will have internet connection as the platform becomes available to the stakeholders.
- Stakeholders will have adequate resource endowment to implement recommendations from this system.

Dependencies:

- The performance of the project also relies on the accessibility of pre-existing AI models in addition to whether they are suitable for the system.

- It depends on other various assets like IoT devices and the cloud for data capture and analysis.
- Probably, some extra funding or support from other environmental organizations may be necessary for the large-scale application of the techniques.

3. External Interface Requirements

3.1. Hardware Interfaces

1. IoT Device Requirements:

ESP32 Microcontroller:

- Supports Wi-Fi connectivity to transmit sensor data to the server in real-time.
- Includes GPIO pins for connecting DHT11 and MQ135 sensors, ensuring seamless integration and communication.

DHT11 Sensor:

- Measures environmental temperature and humidity with reasonable accuracy for effective analysis.
- Simple communication protocol to ensure compatibility with ESP32 GPIO pins.

MQ135 Sensor:

- Monitors air quality index (AQI) by detecting gases such as CO_2, NH_3, NO_x, and benzene in the environment.
- Delivers analog output signals that the ESP32 can process for real-time AQI measurements.

Power Supply:

- Each IoT device requires a stable and continuous power source, such as a reliable AC-to-DC adapter or battery, to ensure uninterrupted functionality.
- Must include surge protection mechanisms to safeguard electronic components against voltage fluctuations.

2. **Server Requirements:**

RAM:

- Minimum 8GB for efficient handling of real-time data processing and machine learning computations.

CPU:

- At least a 4-core processor to support concurrent API requests and sensor data analysis.

Network:

- High-speed internet connection to ensure uninterrupted communication with IoT devices.
- Reliable uptime to ensure uninterrupted communication between IoT devices and the server.

3.2. Software Interfaces

1. **Database:**

MongoDB:

- Stores structured IoT device data, model predictions, and detailed analysis results in JSON format.
- Ensures high availability and scalability to accommodate increasing data storage needs as more devices are deployed.
- Provides indexing and querying features for efficient data retrieval and integration with machine learning workflows.

2. **AI and ML Frameworks:**

Models for Comparison:

Support Vector Machine (SVM):

- Uses a hyperplane to separate input data into categories of favorable and unfavorable tree plantation locations.
- Leverages key sensor parameters such as temperature, humidity, and AQI for classification.

Random Forest:

- Implements an ensemble of decision trees to perform robust classification by aggregating multiple outcomes.
- Evaluates suitability for tree plantation through insights derived from diverse environmental parameters.

Models for Prediction:

Neural Networks:

- Fully connected feedforward networks used to predict future environmental metrics (e.g., AQI, temperature, humidity) based on historical data.

1D Convolutional Neural Networks (1D CNNs):

- Utilized to capture patterns in time-series sensor data and make accurate predictions about environmental changes post-plantation.

Integration:

- The ML models interact with the stored data in MongoDB to perform location comparisons and generate predictions.

3. External Platforms:

Versal.com:

- Versal.com for live hosting of dashboards and visualizing system performance.
- Ensures high accessibility and uptime to monitor the project's progress remotely.

3.3. Communications Interfaces

1. **Data Transmission:**
   - IoT devices use Wi-Fi to send data every 5 minutes to the server.
   - MQTT protocol for lightweight and reliable message queuing.
2. **Data Format:**

- JSON format for exchanging data between devices, databases, and dashboards.

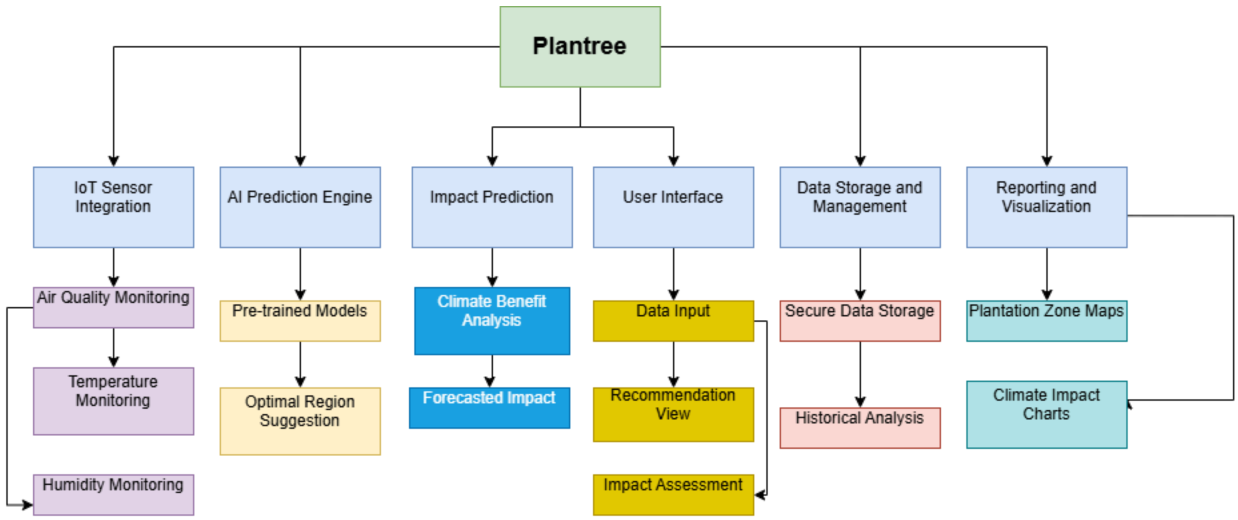
3. Monitoring and Logging:

- Use logging frameworks (e.g., Python’s logging library) to track sensor data uploads and model predictions.
- Logs include timestamps, device IDs, and error details for traceability.

4. Functional Requirements

4.1. Functional Hierarchy

This section presents a comprehensive overview of the overall system functionality for the "Plantree" project. The system will be divided into main modules and sub-functions to provide a clear understanding of the overall structure and purpose of the system. The primary modules include:



- **IoT Sensor Integration:**

  This module handles data collection from IoT sensors such as MQ135, ESP32, and DHT11. It monitors environmental parameters such as air quality, humidity, and temperature.

- **AI Prediction Engine:**

  The core of the system utilizes pre-trained AI models (SvM, Random Forest, Neural Network and 1D CNN) to process sensor data and recommend optimal tree plantation regions.

- **Impact Prediction:**

  This module analyzes and predicts the climate benefits of suggested tree plantation regions based on the collected data.

- **User Interface:**

A user-friendly interface for organizations and foundations to interact with the system. It includes features to input data, view recommendations, and assess the impact predictions.

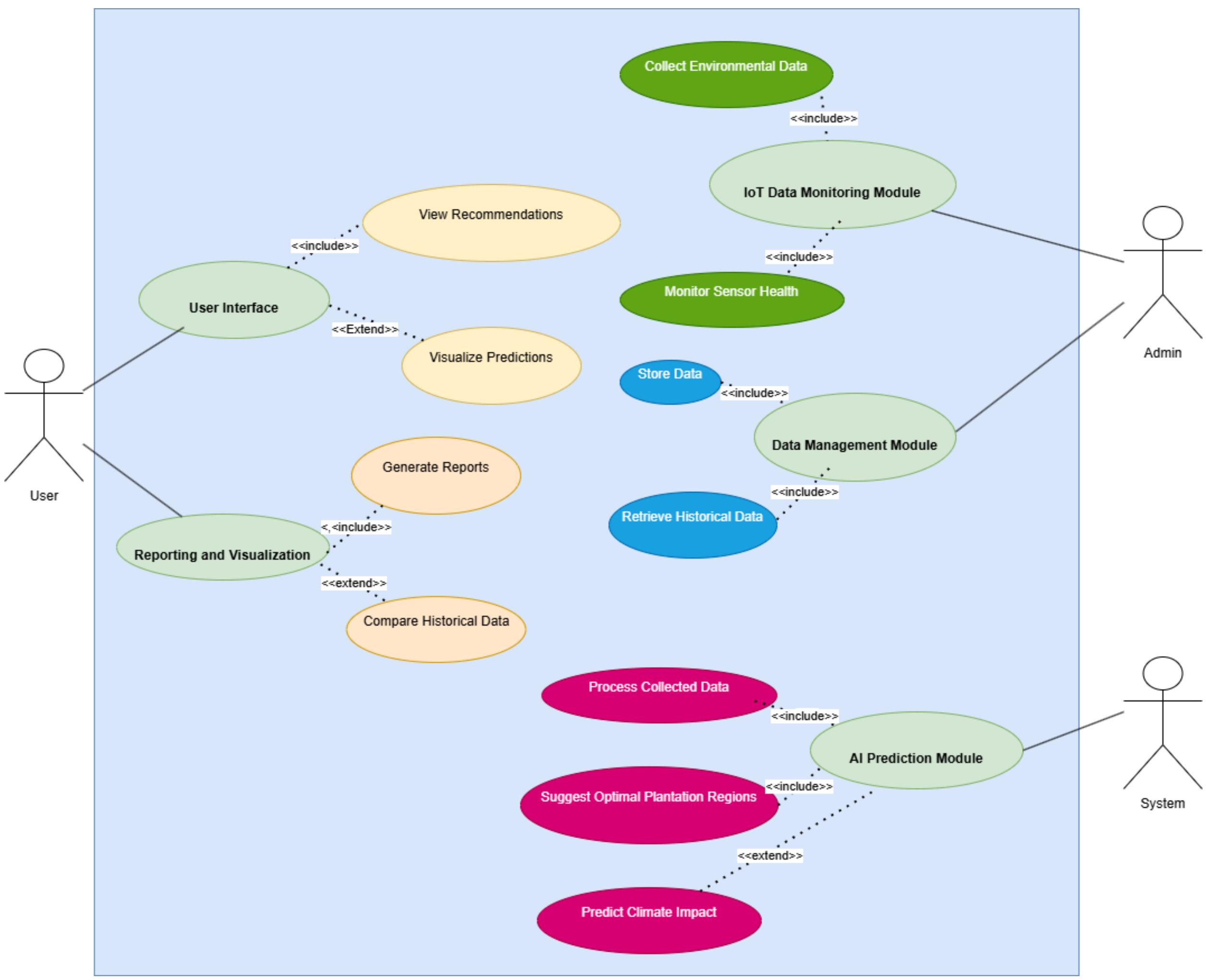
- **Data Storage and Management:**

  Ensures all environmental data and predictions are stored securely for analysis and historical insights.

- **Reporting and Visualization:**

  Provides visual representations of recommended plantation zones and predicted impacts for user understanding.

4.2. Use Cases



4.2.1. Predict Optimal Tree Plantation Region

UC1 - Predict Optimal Tree Plantation Region		
Use case Id:	UC1	
Actors:	Environmental Organizations, System Administrator	
Feature:	Regional Prediction for Tree Plantation	
Pre-condition:	IoT sensors (MQ135, ESP32, DHT11) are set up in the target region and operational.	
Scenarios		
Step#	**Action**	**Software Reaction**
1.	User inputs the region's coordinates.	System retrieves sensor data
2.	User requests AI-based prediction	System uses AI models to analyze data and provides an optimal tree plantation recommendation
Alternate Scenarios:		
1a: If sensor data is missing, the system notifies the user to check connectivity **2a:** If the region has insufficient climate data, suggest the closest region with valid data		
Post Conditions		
Step#	**Description**	
1.	User receives recommendations for tree plantation areas with data-driven reasoning	
Use Case Cross referenced	None	

4.2.2. Monitor Air Quality

UC2 - Monitor Air Quality		
Use case Id:	UC2	
Actors:	Campaign Coordinators, System Administrator	
Feature:	Air Quality Monitoring	
Pre-condition:	MQ135 sensor is calibrated and operational	
Scenarios		
Step#	**Action**	**Software Reaction**
1.	User activates air quality monitoring	The system collects air quality data from the sensor
2.	User requests an air quality report	System generates a report with suggestions for improvement
Alternate Scenarios:		
1a: If the sensor is malfunctioning, display an error and suggest a reset		
Post Conditions		
Step#	**Description**	
1.	Air quality data is logged for analysis	
Use Case Cross referenced	UC1	

4.2.3. Analyze Temperature and Humidity Data

UC3- Analyze Temperature and Humidity Data		
Use case Id:	UC3	
Actors:	Climate Researchers, Tree Plantation Managers	
Feature:	Environmental Data Analysis	
Pre-condition:	DHT11 sensor is installed and operational	
Scenarios		
Step#	**Action**	**Software Reaction**
1.	User requests temperature and humidity data	System fetches real-time data from DHT11 sensors
2.	User initiates analysis	AI models analyze data trends and provide insights
Alternate Scenarios:		
1a: If data is incomplete, notify the user to adjust sensor placement		
Post Conditions		
Step#	**Description**	
1.	User receives a detailed analysis of temperature and humidity trends	
Use Case Cross referenced	UC1	

4.2.4. Train AI Models with New Data

UC4 - Train AI Models with New Data		
Use case Id:	UC4	
Actors:	Data Scientists, System Administrator	
Feature:	AI Model Training	
Pre-condition:	Historical data is available in the database	
Scenarios		
Step#	**Action**	**Software Reaction**
1.	User uploads new training data	System validates the data format and quality
2.	User initiates model training	System retrains AI models and stores updated versions
Alternate Scenarios:		
1a: If data validation fails, notify the user with an error report		
Post Conditions		
Step#	**Description**	
1.	AI models are updated with the latest data	
Use Case Cross referenced	UC1, UC3	

4.2.5. Predict Climate Impact Post-Plantation

UC5 - Predict Climate Impact Post-Plantation		
Use case Id:	UC5	
Actors:	Environmental Organizations	
Feature:	Post-Plantation Climate Prediction	
Pre-condition:	AI model is trained with accurate historical data	
Scenarios		
Step#	**Action**	**Software Reaction**
1.	User inputs plantation data (e.g., tree species, number of trees)	System runs the prediction model
2.	User views prediction results	System generates an impact report
Alternate Scenarios:		
1a: If input data is incomplete, suggest corrections to the user		
Post Conditions		
Step#	**Description**	
1.	Prediction results are shared with the user	
Use Case Cross referenced	UC4	

4.2.6. Generate Tree Plantation Campaign Reports

UC6 - Generate Tree Plantation Campaign Reports		
Use case Id:	UC6	
Actors:	Environmental Organizations, Campaign Managers	
Feature:	Report Generation	
Pre-condition:	Campaign data and IoT sensor data are available in the system	
Scenarios		
Step#	**Action**	**Software Reaction**
1.	User requests a campaign performance report	System processes plantation data, sensor readings, and AI predictions
2.	User specifies the report format (e.g., PDF, CSV)	System generates the report in the selected format and sends it to the user
Alternate Scenarios:		
1a: If any data is missing, the system highlights gaps and suggests remedies		
Post Conditions		
Step#	**Description**	
1.	User receives a detailed campaign report	
Use Case Cross referenced	UC1, UC5	

4.2.7. Configure IoT Sensors

UC7 - Configure IoT Sensors		
Use case Id:	UC7	
Actors:	System Administrator, Technical Staff	
Feature:	Sensor Configuration	
Pre-condition:	Sensors are physically installed but not configured	
Scenarios		
Step#	**Action**	**Software Reaction**
1.	User logs in as an administrator	System grants access to sensor settings.
2.	User configures sensor thresholds and calibration settings	System updates sensor configurations and tests the connection
Alternate Scenarios:		
1a: If sensor calibration fails, provide troubleshooting instructions		
Post Conditions		
Step#	**Description**	
1.	Sensors are fully configured and operational	
Use Case Cross referenced	UC2, UC3	

4.2.8. Notify Users of Critical Environmental Changes

UC8 - Notify Users of Critical Environmental Changes		
Use case Id:	UC8	
Actors:	Environmental Organizations, Plantation Managers	
Feature:	Critical Environmental Alerts	
Pre-condition:	System is actively monitoring sensor data	
Scenarios		
Step#	**Action**	**Software Reaction**
1.	System detects critical changes (e.g., high pollution levels, temperature spikes)	Generates an automatic notification to users
2.	User acknowledges the notification	System records acknowledgment and provides recommendations
Alternate Scenarios:		
1a: If no response from users, escalate the alert via SMS or email		
Post Conditions		
Step#	**Description**	
1.	Users are informed of critical environmental conditions	
Use Case Cross referenced	UC2, UC3	

4.2.9. Compare Plantation Regions

UC9 - Compare Plantation Regions		
Use case Id:	UC9	
Actors:	Researchers, Campaign Managers	
Feature:	Regional Comparison for Tree Plantation	
Pre-condition:	Data from multiple regions is available in the system	
Scenarios		
Step#	**Action**	**Software Reaction**
1.	User selects regions to compare	System retrieves and analyzes data from selected regions
2.	User views a comparative report	System generates a detailed report highlighting advantages and disadvantages of each region
Alternate Scenarios:		
1a: If data is insufficient for a region, notify the user and exclude it from the comparison		
Post Conditions		
Step#	**Description**	
1.	User gains insights into the most suitable plantation regions	
Use Case Cross referenced	UC1, UC6	

4.2.10. Predict Seasonal Plantation Success

UC10 - Predict Seasonal Plantation Success		
Use case Id:	UC10	
Actors:	Environmental Organizations, Researchers	
Feature:	Seasonal Prediction for Plantation Success	
Pre-condition:	Historical seasonal data and weather forecasts are available	
Scenarios		
Step#	**Action**	**Software Reaction**
1.	User selects a target planting season	System analyzes historical and forecasted climate data for the season
2.	User views the seasonal plantation success prediction	System provides a detailed prediction report, including suggestions for tree species
Alternate Scenarios:		
1a: If weather forecasts are unavailable, rely on historical seasonal data only		
Post Conditions		
Step#	**Description**	
1.	User receives actionable insights for seasonal planting success	
Use Case Cross referenced	UC1, UC3	

5. Non-functional Requirements

5.1. Performance Requirements

NFR-PR1	The system must ensure all devices send temperature, humidity, and AQI data to MongoDB every 5 minutes without delays or missing records.
NFR-PR2	MongoDB should handle storage of up to 1 million sensor records and retain data for at least one year for analysis.
NFR-PR3	The machine learning comparison model must process data from all four devices and generate results in under 30 seconds.
NFR-PR4	Prediction models for environmental impact after tree plantation must deliver results in less than 20 seconds.
NFR-PR5	The system must be capable of processing data from up to 10 devices without experiencing performance degradation.
NFR-PR6	Data on the Versal.com dashboard must refresh within 10 seconds after receiving updated readings from devices.
NFR-PR7	The Versal.com platform must achieve 99.9% uptime, ensuring consistent access to live environmental data.
NFR-PR8	Alerts for abnormal sensor readings, such as extreme AQI values, must be displayed on the dashboard within 5 seconds.
NFR-PR9	Devices should automatically reconnect to Wi-Fi within 1 minute if a connection is lost and resume data transmission.
NFR-PR10	The system should support real-time monitoring of all locations, updating graphs every second for visual clarity.
NFR-PR11	Devices must function reliably in outdoor conditions ranging from 0°C to 55°C to ensure consistent operation in Karachi.
NFR-PR12	Each device must handle power fluctuations without resetting or losing collected data, ensuring uninterrupted functionality
NFR-PR13	The comparison ML model should scale efficiently when

	additional devices or regions are added.
NFR-PR14	The system should allow exporting device readings in CSV format within 10 seconds for external analysis.
NFR-PR15	The system must synchronize all devices within 10 seconds to ensure data timestamps remain consistent.
NFR-PR16	The dashboard must visually highlight the most suitable location for tree plantation based on live data in real time.
NFR-PR17	All devices and software components must integrate seamlessly to avoid delays or conflicts during data processing.

5.2. Safety Requirements

NFR-SFR1	Sensors must be housed in weatherproof enclosures, adhering to IP65 standards to resist dust and water exposure.
NFR-SFR2	Power backup systems must ensure devices remain functional for up to 1 hour during electricity outages in Karachi.
NFR-SFR3	Any data loss during transmission must trigger an alert and a retry mechanism to recover the missing records.
NFR-SFR4	Devices must be securely mounted to avoid damage from environmental factors like wind or accidental tampering.
NFR-SFR5	Data transmission errors must be logged for diagnostics and flagged for manual review.
NFR-SFR6	All devices must undergo monthly maintenance and calibration to maintain sensor accuracy and ensure reliable data.
NFR-SFR7	Tree plantation sites must follow safety protocols to avoid risks like flooding or soil instability.
NFR-SFR8	Devices must automatically reconnect to Wi-Fi within one minute after a network outage to resume data transmission.

NFR-SFR9	Battery-operated emergency systems must activate if power cuts exceed an hour, keeping the device operational.
NFR-SFR10	Sensor enclosures must prevent tampering or unauthorized removal during outdoor deployment.
NFR-SFR11	Data collection must stop if devices detect environmental conditions harmful to hardware, such as high moisture levels.
NFR-SFR12	On-site inspections must occur monthly to ensure device enclosures and power supplies are intact.
NFR-SFR13	All deployment locations must be selected to minimize risks like vandalism, theft, or accidental damage.
NFR-SFR14	AQI readings above 500 must generate immediate alerts to inform about hazardous environmental conditions.

5.3. Security Requirements

NFR-SCR1	Devices must connect to secured Wi-Fi networks only, with WPA2 encryption enabled.
NFR-SCR2	Regular security audits must be conducted on MongoDB and the dashboard to identify vulnerabilities.
NFR-SCR3	Firmware updates for ESP32 devices must only be applied via secure channels to avoid unauthorized changes.
NFR-SCR4	Only encrypted APIs should be used for data retrieval and integration between the system's components.
NFR-SCR5	Sensitive data must not be stored in plaintext on MongoDB; anonymization must be applied if needed.
NFR-SCR6	Project administrators must be trained on proper handling of user credentials and data access protocols.
NFR-SCR7	Wi-Fi passwords for devices must be changed every 30 days to minimize the risk of unauthorized access.

NFR-SCR8	A timeout system must log out inactive users from the Versal.com dashboard after 15 minutes.
NFR-SCR9	Data exported from MongoDB must be protected with encryption if shared externally.
NFR-SCR10	Suspicious activity, such as unusually high data transmission rates, must trigger an investigation alert.
NFR-SCR11	MongoDB access must be logged for every action, including who accessed it and what changes were made.
NFR-SCR12	The dashboard must display a warning if a device connects from an unauthorized location or IP address.

6. References

Reference 01:

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Reference 02:

[2] K. L. Bowler et al., "Urban greening to cool towns and cities: A systematic review of the empirical evidence," Landscape and Urban Planning, vol. 182, pp. 12-24, 2019.

Reference 03:

[3] T. K. Patil et al., "An IoT Based Air Pollution Monitoring System for Smart Cities," Journal of Urban Technology, 2021.

Reference 04:

[4] P. Zhang et al., "Artificial Intelligence in Green Building," Energy and Buildings, vol. 247, 2021.

Reference 05:

[5] S. Lee et al., "Urban Vegetation Mapping from Aerial Imagery Using Explainable AI," IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 14, 2021.

7. Appendices

This glossary provides definitions for terms and abbreviations used in this document.

Artificial Intelligence (AI):
The simulation of human intelligence in machines programmed to think and learn. AI is used in this project to analyze environmental data and provide insights for tree plantations.

Internet of Things (IoT):
A system of interconnected devices that communicate over the internet to collect and exchange data. In this project, IoT devices like ESP32 collect temperature, humidity, and AQI data for analysis.

ESP32 Microcontroller:
A low-power system-on-chip microcontroller with integrated Wi-Fi and Bluetooth, used to collect and transmit environmental data from sensors to the server.

DHT11 Sensor:
A digital sensor designed to measure temperature and humidity with moderate accuracy. It is connected to the ESP32 for environmental data collection.

MQ135 Sensor:
A sensor that measures air quality by detecting gases such as CO2, NH3, and NOx. It provides analog signals processed by the ESP32 microcontroller.

Predictive Analytics:
The process of using statistical algorithms and machine learning techniques to predict future environmental conditions, such as the impact of tree plantation on air quality and temperature.

GRU (Gated Recurrent Unit):
A type of recurrent neural network (RNN) used for processing sequential data, such as time-series measurements of temperature, humidity, and AQI..

Air Quality Index (AQI):
A measure of air pollution that indicates how clean or polluted the air is and its potential health impacts. MQ135 sensors provide the AQI used in plantation analysis.

Secure Wi-Fi Network:
Wi-Fi with WPA2 encryption ensures secure communication between IoT devices and the server, protecting sensitive data.

MongoDB:
A NoSQL database used to store structured environmental data collected by sensors, along with predictions and reports generated by the AI models.

Environmental Sensors:
Devices such as DHT11 and MQ135 that collect real-time data on temperature, humidity, and air quality, enabling location-specific recommendations.

Tree Plantation Impact Prediction:
The use of AI models to forecast the long-term benefits of tree plantation on environmental factors, such as air quality improvement and temperature regulation.

Weatherproof Enclosures:
Enclosures rated IP65 to protect IoT devices from environmental elements such as dust, rain, and high humidity, ensuring uninterrupted operation.

Data Timestamping:
The process of recording the exact time a data point is collected, ensuring chronological accuracy for analysis.

Billion Tree Tsunami:
A large-scale tree plantation campaign initiated in Pakistan, one of the potential beneficiaries of this project's data-driven recommendations.

MTJ (Maulana Tariq Jameel):
A foundation engaged in tree plantation campaigns, serving as a primary stakeholder for