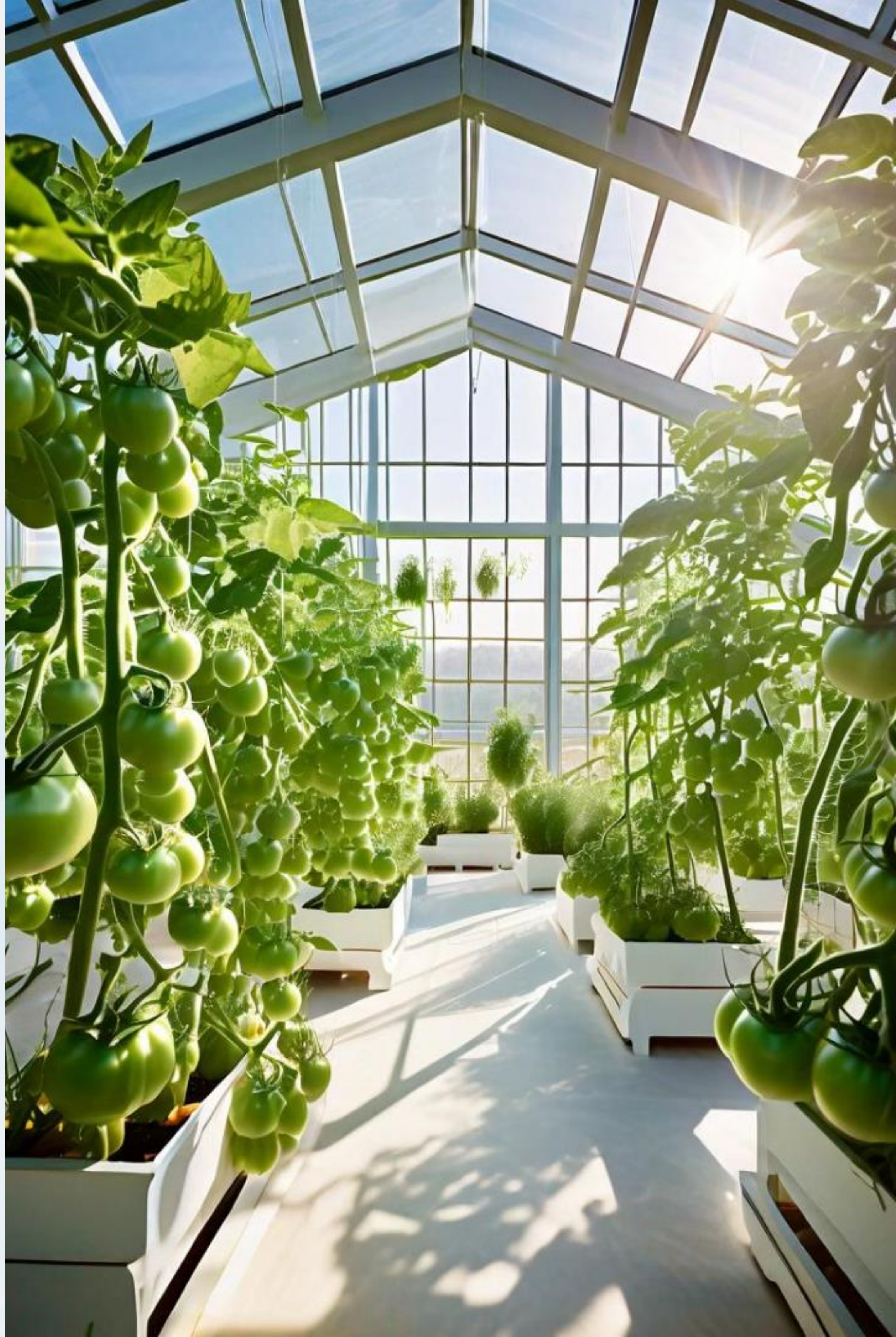
SMART GREENHOUSES DECISION SUPPORT SYSTEMS SYSTEMS FOR TOMATO CULTIVATION

GROUP ID: 24-25J-064



Introduction

Maintaining optimal conditions in tomato greenhouses is crucial for maximizing yield and quality. This project aims to develop a comprehensive system that leverages real-time environmental data to predict optimal watering schedules, fertilizing schedules and types, harvesting schedules, and provides recommendations for tomato diseases, ensuring sustainable tomato cultivation.

GROUP MEMBER AND SUPERVISORS DETAILES

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SUPERVIISORS
SUPERVISOR – Mrs. Geethanjali Wimalaratne
CO-SUPERVISOR – Mr. Samantha Thelijjagoda

Research Question

What is the optimal combination of watering schedules, fertilizing schedules and types, harvesting schedules, and disease management strategies to maximize the yield and health of tomatoes in smart greenhouses?

Objectives

•**Optimize Watering Schedules**

•Determine the best timing and frequency for watering to ensure healthy growth and efficient water use.

•**Optimize Fertilizing Schedules and Types**

•Identify the most effective fertilizing routines and products to enhance nutrient availability and promote robust tomato plants.

•**Optimize Harvesting Schedules**

•Establish the ideal timing for harvesting tomatoes to maximize yield and quality.

•**Tomato Disease Management**

•Develop strategies to identify, prevent, and treat common tomato diseases and provide recommendations to maintain plant health.

IT21181160 | THRIMAVITHANA V. D.

Information Technology

Introduction

The Effects of Fertilization on Tomato Crops:

- Climate change alters nutrient availability in soil, impacting tomato production and quality.
- Proper fertilization is essential for tomato crops to ensure they receive the necessary nutrients for optimal growth and development.
- Both over-fertilization and under-fertilization can negatively affect tomato yield and quality.

Challenges of Fertilization:

- **Over-fertilization:** Leads to nutrient leaching, soil and water pollution, and potential plant toxicity.

- **Under-fertilization:** Results in nutrient deficiencies, poor plant growth, and reduced yields.

Environmental Factors Affecting Fertilizing of Tomatoes

Temperature's Influence:

•Higher temperatures: Increased nutrient absorption and faster depletion.

•Optimal range: 20°C to 26°C.

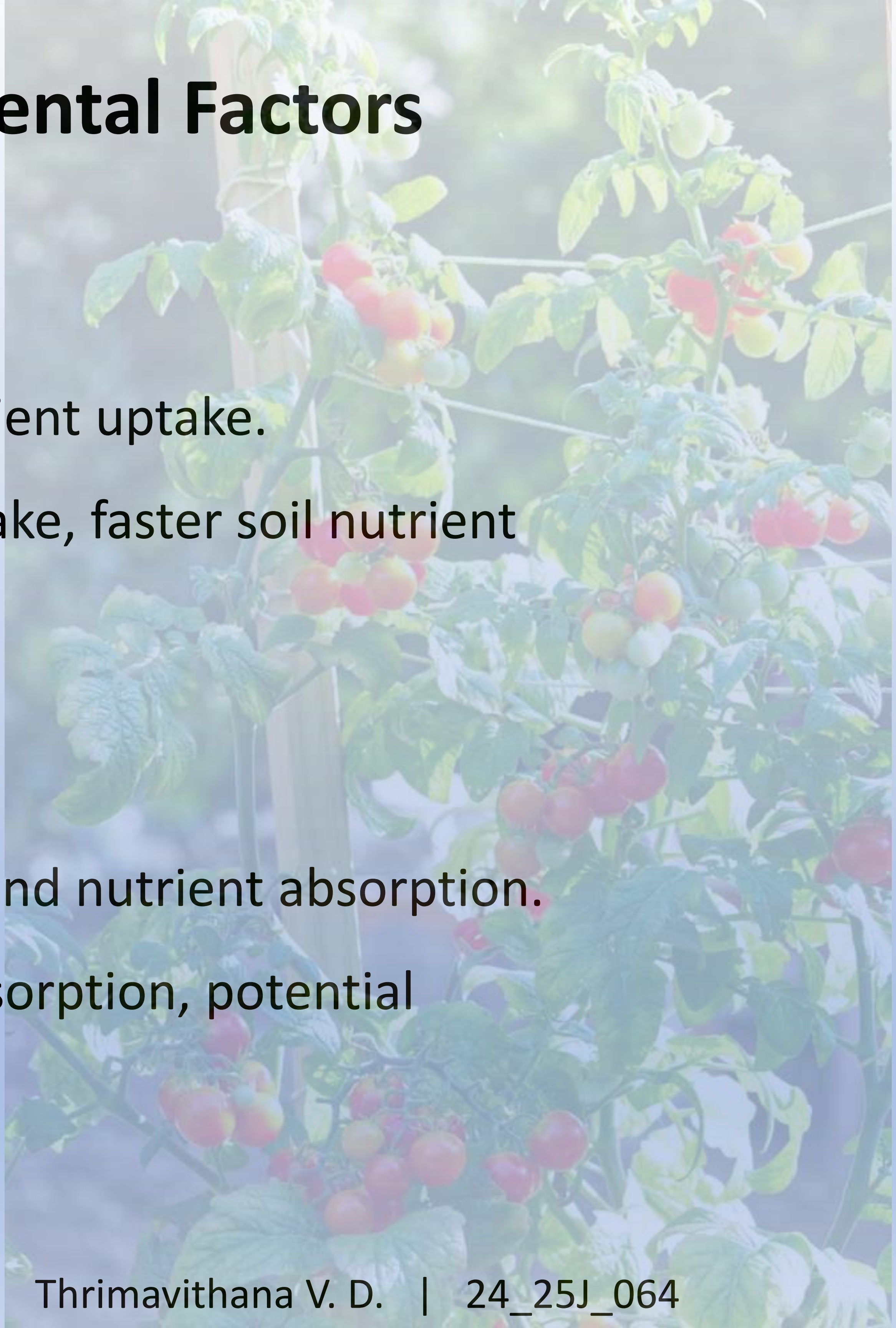
•Low temperatures: Slower uptake, potential nutrient lock-up.

Challenges of Temperature Extremes:

•High temperatures: Nutrient imbalances, nitrogen loss, frequent fertilization.

•Low temperatures: Risk of over-fertilization, nutrient leaching.

Additional Environmental Factors



Humidity Levels:

- High humidity: Reduced nutrient uptake.
- Low humidity: Increased uptake, faster soil nutrient depletion.

Light Intensity:

- Essential for photosynthesis and nutrient absorption.
- Low light: Slower nutrient absorption, potential deficiencies.

Soil Moisture:

- Necessary for nutrient dissolution and uptake.
- Overly wet: Nutrient leaching, poor root oxygenation.
- Dry soil: Limited nutrient availability, plant stress.

Research Gap

Existing Products / Research	Features						
	Automated Fertilizer Application	Real-Time Nutrient Monitoring	Precision Nutrient Delivery	Environmentally Sustainable Practices	Integration with IoT and Sensors	Impact on Fruit Quality	Predictive Analytics for Nutrient Needs
IoT-Based Precision Fertilization System	✓	✗	✓	✗	✓	✗	✗
Smart Fertigation Management System	✓	✓	✗	✗	✗	✓	✗
Integrated Hydroponic Nutrient Solution	✗	✓	✓	✓	✗	✗	✓
Proposed System	✓	✓	✓	✓	✓	✓	✓

Research Question

How can we develop a decision support system for tomato greenhouses that optimizes fertilizing schedules and types that ensures nutrient balance based on real-time plant and environmental conditions?

Objectives

Develop a comprehensive system to optimize fertilizing schedules, determine the precise amount of nutrients needed, and ensure nutrient balance.

Monitor Nutrient Levels and Plant Health

•Use sensors to track nutrient concentrations.

Predict Optimal Fertilizing Times

•Use data to determine the best times to apply fertilizers based on environmental and plant conditions.

Fertilizer Types:

Organic Fertilizers

•Compost

•Manure

•Bone meal

•Fish emulsion

Synthetic Fertilizers

•Nitrogen-based fertilizers (e.g., urea, ammonium nitrate)

•Phosphorus-based fertilizers (e.g., superphosphate, triple superphosphate)

•Potassium-based fertilizers (e.g., potassium chloride, potassium sulfate)

Liquid Fertilizers

•Liquid organic fertilizers (ex: fish emulsion)

•Liquid synthetic fertilizers (ex: nutrient solutions for hydroponics)

Literature Review

Effective fertilization is key to maximizing tomato yield and quality in smart greenhouses.

Automated systems like hydroponics and fertigation further enhance nutrient delivery (Smith et al., 2022; Chen et al., 2023; Garcia et al., 2022).

Other than these, more research is needed to integrate fertilization with other environmental controls, develop predictive models for optimal fertilization, and study long-term effects (Taylor & Evans, 2023; Harris & Clark, 2024).

System Overview

Real-Time Monitoring gathers data on nutrients, plant growth, and environment.

Automated Fertilization delivers nutrients precisely using advanced systems.

Predictive Analytics forecasts the best fertilization strategies.

Centralized Dashboard provides alerts and visualizations to aid in decision-making.

Methodology

1. Gather soil, nutrient data and environmental conditions.
2. Collect historical fertilization schedules and crop yield data.
3. Preprocess the data to handle missing values and normalize it.
4. Choose appropriate hybrid ML models.
5. Train the models using the preprocessed data to optimize fertilization schedules.

Technologies

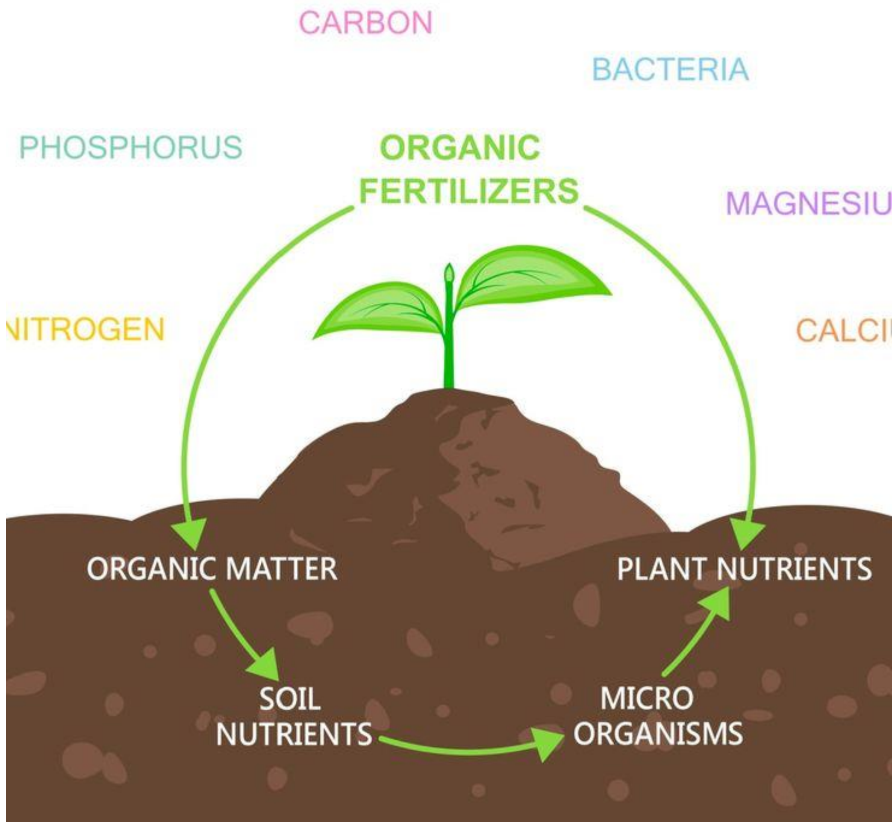
- IoT Devices
- Firebase/ MongoDB
- Python
- Node
- Intellij Idea

Requirements

- **Climate Control**: Automated temperature and humidity systems with sensors.
- **Nutrients**: Automated delivery with EC and pH sensors.
- **Monitoring**: Sensors for temperature, humidity, and CO_2.
- **Data**: IoT sensors
- **Control**: Software for managing systems with a user interface.
- **Algorithms**: Machine learning and optimization for growth and resources.

Non-Functional Requirements

- Performance
- Reliability
- Usability
- Security
- Maintainability
- Compliance
- Cost Efficiency
- Environmental Impact



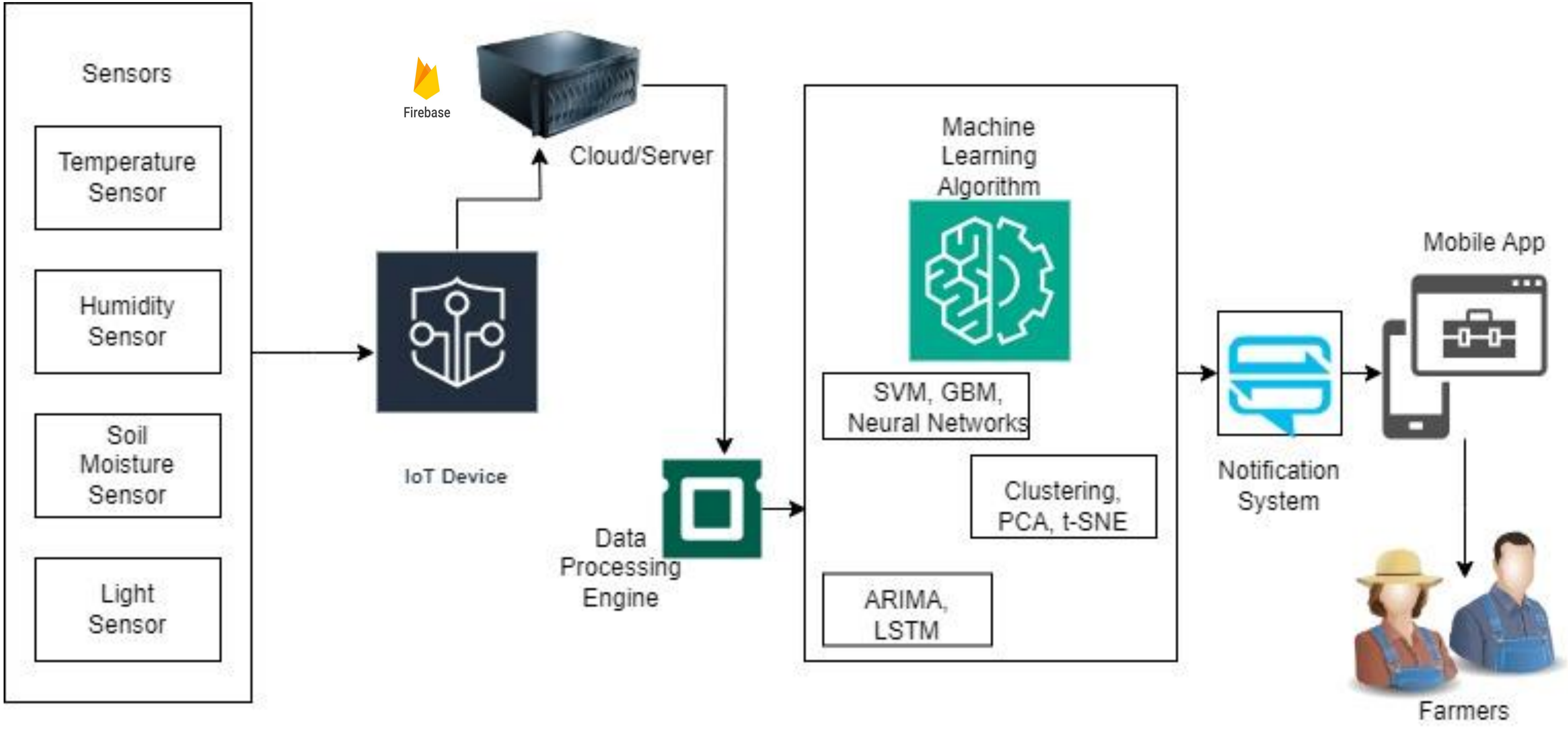
Personnel Requirements

Mr. Krishantha Jayawardhana,
Agrarian Services Center,
Monaragala.

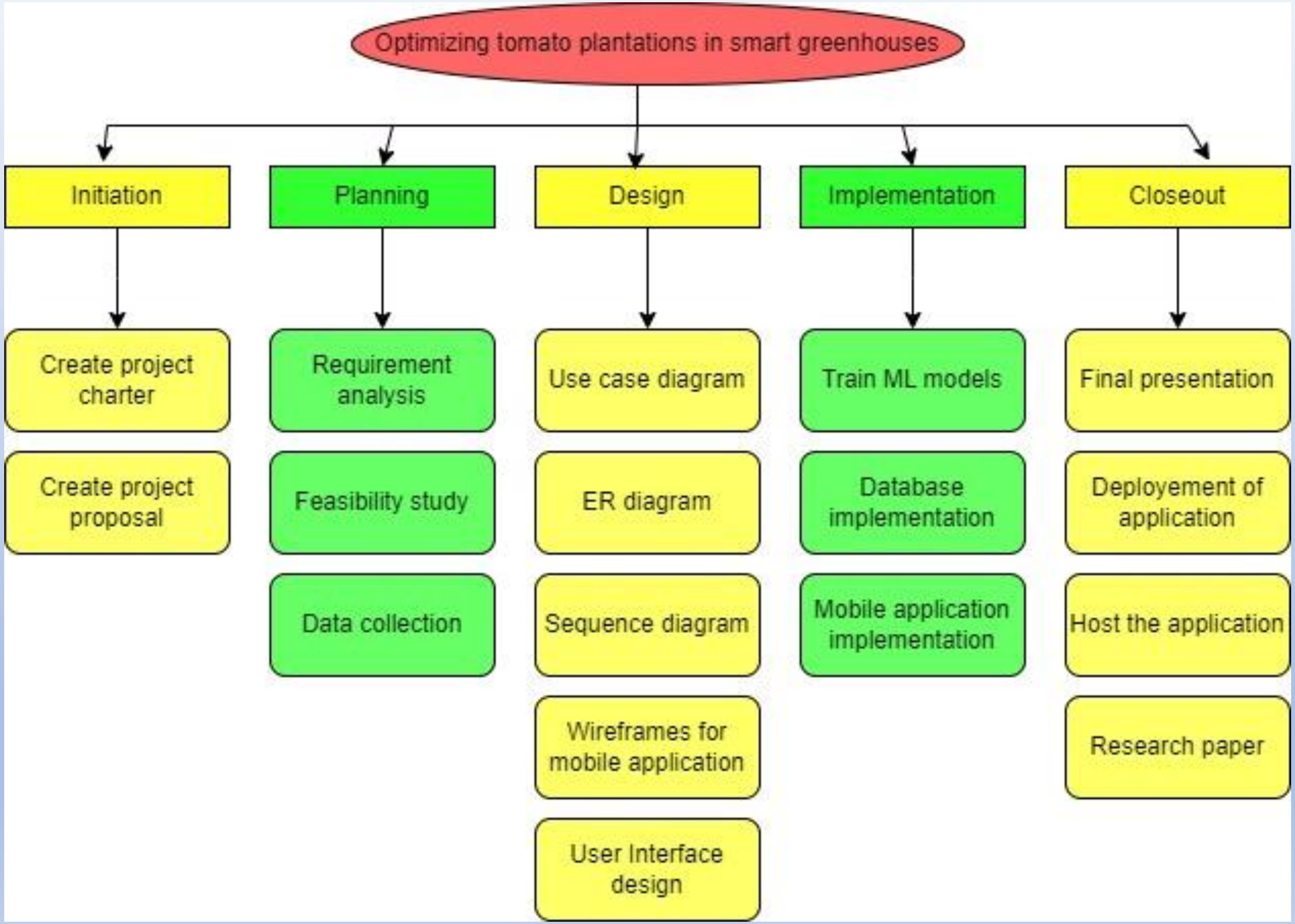
Software Requirements

Database Management System (DBMS) : PostgreSQL, Firebase
Data Integration Tool : Talend
Programming Languages : Python (libraries: Pandas, NumPy, Scikit-Learn), R (For statistical analysis and visualizations)
Data Processing Libraries : Pandas, NumPy, SciPy
Machine Learning Frameworks : Scikit-Learn, TensorFlow
Data Visualization Tools : Matplotlib, Plotly
Notification Services : Firebase Cloud Messaging (FCM)
Mobile Application Development : React Native / (Android Studio/Xcode)
Backend Framework : Node.js
Frontend Frameworks : React.js, Vue.js
APIs : RESTful APIs
Version Control : Git/GitHub

System diagram



Work Breakdown Structure



Target Audience

- Agricultural Researchers
- Greenhouse owners
- Greenhouse Farmers
- Stakeholders
- External Parties

Market Place

- No need of advanced knowledge in technology.
- No age limit for the users.

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IT21231896 | ASARDEEN A.

Specialization : Information Technology

Background

❑ The effects of Water Irrigation on Tomato Crops :

- Climate change increases greenhouse temperatures, affecting tomato production and quality.[1]
- Proper irrigation is crucial for tomato crops to ensure they receive the right amount of water for optimal growth.[2]
- Both over-irrigation and under-irrigation can negatively affect tomato yield and quality.[3]

❑ Challenges of Irrigation:

- **Over-irrigation:** Causes root rot, nutrient leaching, and disease promotion.
- **Under-irrigation:** Leads to water stress, fruit cracking, and reduced yields.

Introduction

Background

❑ Temperature's Influence on Water Needs:

- Climate change increases greenhouse temperatures, affecting tomato production and quality.[4]
- Higher temperatures increase the water requirements for tomato plants.[5]
- Optimal temperature range for tomato growth is 20°C to 26°C.

❑ Challenges of High Temperatures:

- Increased water needs.
- Reduced water potential, CO_2 assimilation rates, and stomatal conductance.
- Decreased fruit production and quality

❑ Low Temperatures:

- Slow down plant growth and reduce water uptake.
- Overwatering in cool conditions can lead to root diseases.

Research Gap

Existing Products / Research	Features						
	Automated Water irrigation	**Water Quality & Purity Checking**	**Soil Moisture, Light & Temperature Monitoring**	**Temperature Control**	**Water level & Availability checking**	**Predict Watering Time, Schedule, Quantity**	**Real-Time Alerts (Dashboard)**
IoT-Based Precision Irrigation System	✓	✗	✓	✗	✓	✗	✗
Smart high-yield tomato cultivation System	✓	✗	✗	✗	✓	✗	✓
Indoor Seedling Irrigation System	✗	✗	✓	✗	✗	✗	✗
LoRaWAN based IoT system	✗	✗	✓	✗	✗	✗	✓
Proposed System	✓	✓	✓	✓	✓	✓	✓

Research Question

How can we develop a decision support system for tomato greenhouses that predicts optimal watering schedules and ensures water purity based on real-time environmental conditions?

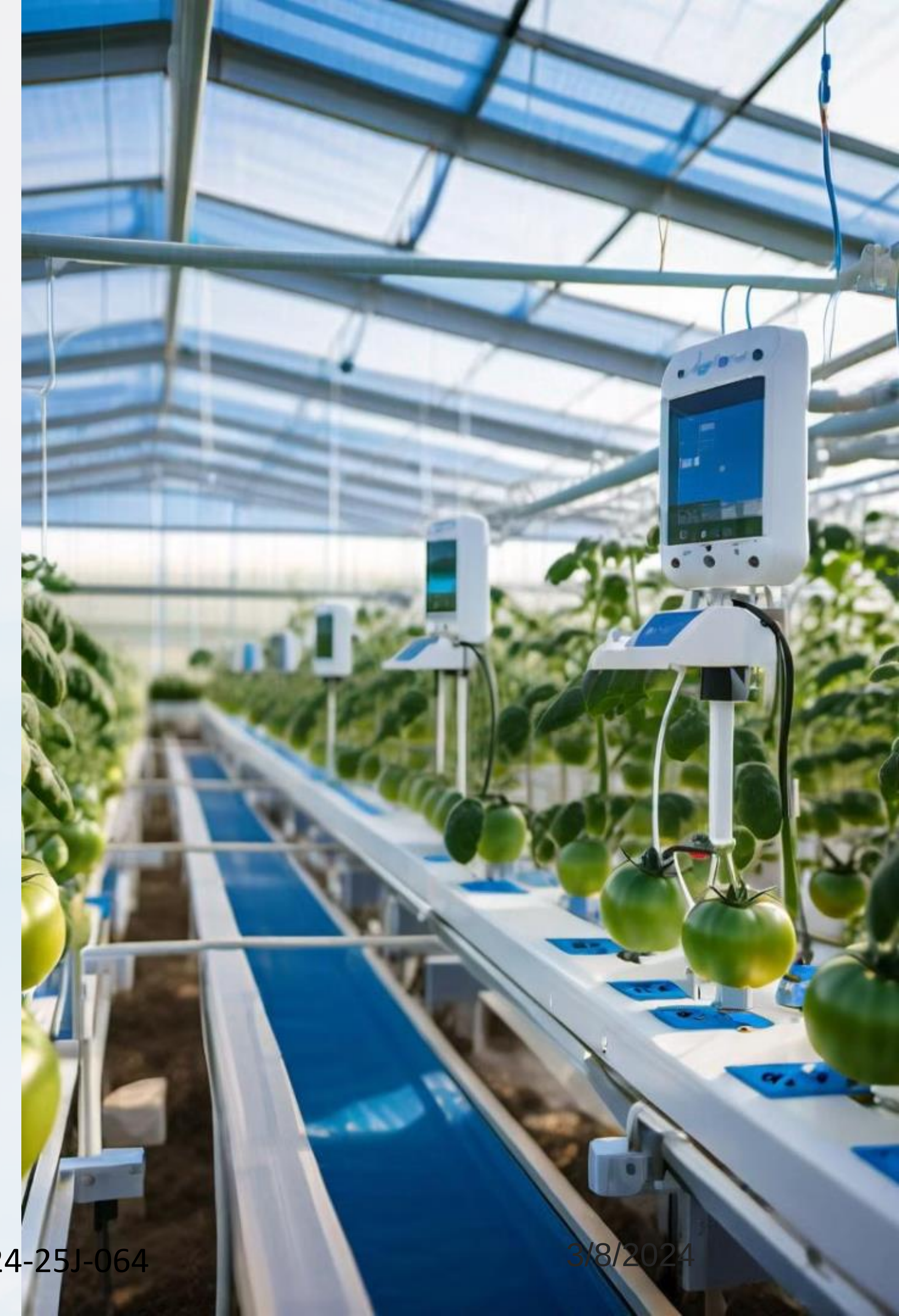
Specific & Sub Objectives

Specific Objective

Develop a comprehensive system to predict the optimal watering schedule, determine the precise amount of water needed, and ensure water availability.

Sub Objective

- Monitor soil moisture and temperature in real-time
- Implement automatic watering and temperature control systems
- Monitor water levels and water availability continuously
- Predict optimal watering times and schedules based on environmental conditions
- Predict water quantity requirements for irrigation
- Provide real-time alerts through a dashboard



Literature Review

Existing smart irrigation systems leverage IoT and machine learning to enhance water efficiency but fall short in predicting optimal watering schedules and total water requirements for specific periods (e.g., daily, weekly, monthly). They also fail to ensure the water is suitable for plant irrigation. Our approach addresses these gaps, optimizing plant health and crop yield

Proposed System Overview

1

Real-time Monitoring

Continuous monitoring of soil moisture, temperature, light, water levels, and water purity.

2

Automated Control

Automatic watering and temperature regulation systems based on environmental environmental conditions.

3

Predictive Analytics

Forecasting optimal watering schedules and daily water quantity requirements.

4

Centralized Dashboard

Real-time alerts and visualization of greenhouse conditions for informed decision-making. decision-making.

Methodology

Technologies

- IoT Devices
- Arduino IDE
- MQTT Services
- Firebase
- Python
- Flask
- Web Tech

Techniques

1. Real-time data collection and and analysis
2. Machine Learning for prediction models
3. Continuous monitoring and and alert systems

Algorithms

- **Machine Learning Models**: Regression algorithms for predicting water quantity and schedule
- **Decision Support Systems**: Rule-based systems for automating actions based on sensor data
- **Time Series Analysis**: ARIMA or LSTM for predicting environmental conditions
- **Control Systems**: PID control for maintaining optimal temperature

Requirements

Hardware requirements

- Microcontroller (ESP32)
- Dc LCD Display
- Power Supply
- Relay Modules
- Jumper Wires
- Breadboard (for prototyping)
- **Sensors :**
  - Soil moisture sensors
  - Temperature sensors
  - Humidity sensors
  - Light sensors
  - Ultrasonic sensor

System requirements

- real-time Sensor Data Collection
- Data Processing and Analysis
- Automated Irrigation Control
- User Interface
- Real-Time Alerts and Notifications
- Water Quality Monitoring
- Temperature Control
- Allow Manual Override

Non-functional requirements

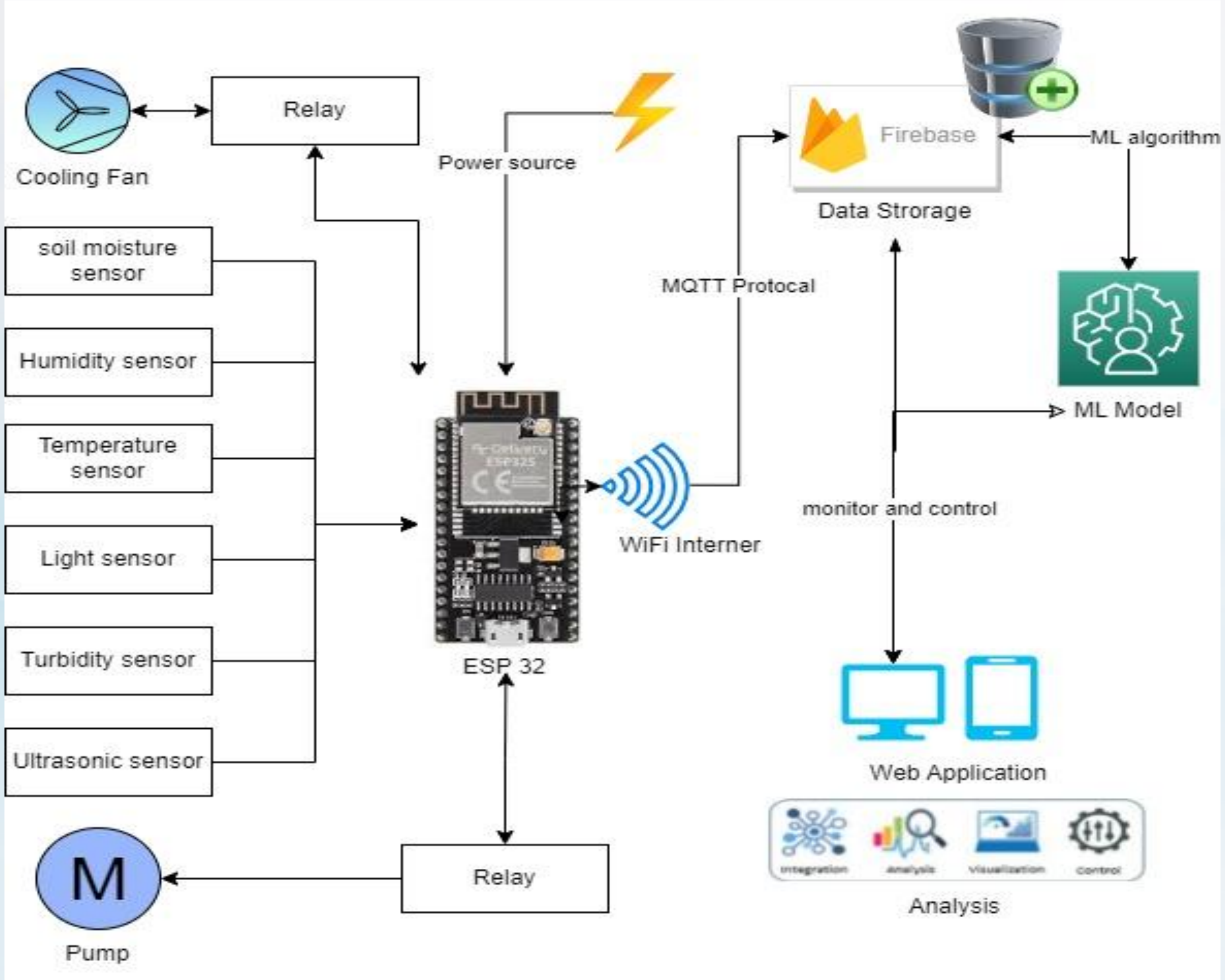
- Performance
- Reliability
- Scalability
- Security
- Usability
- Maintainability
- Accuracy

Completion of the project

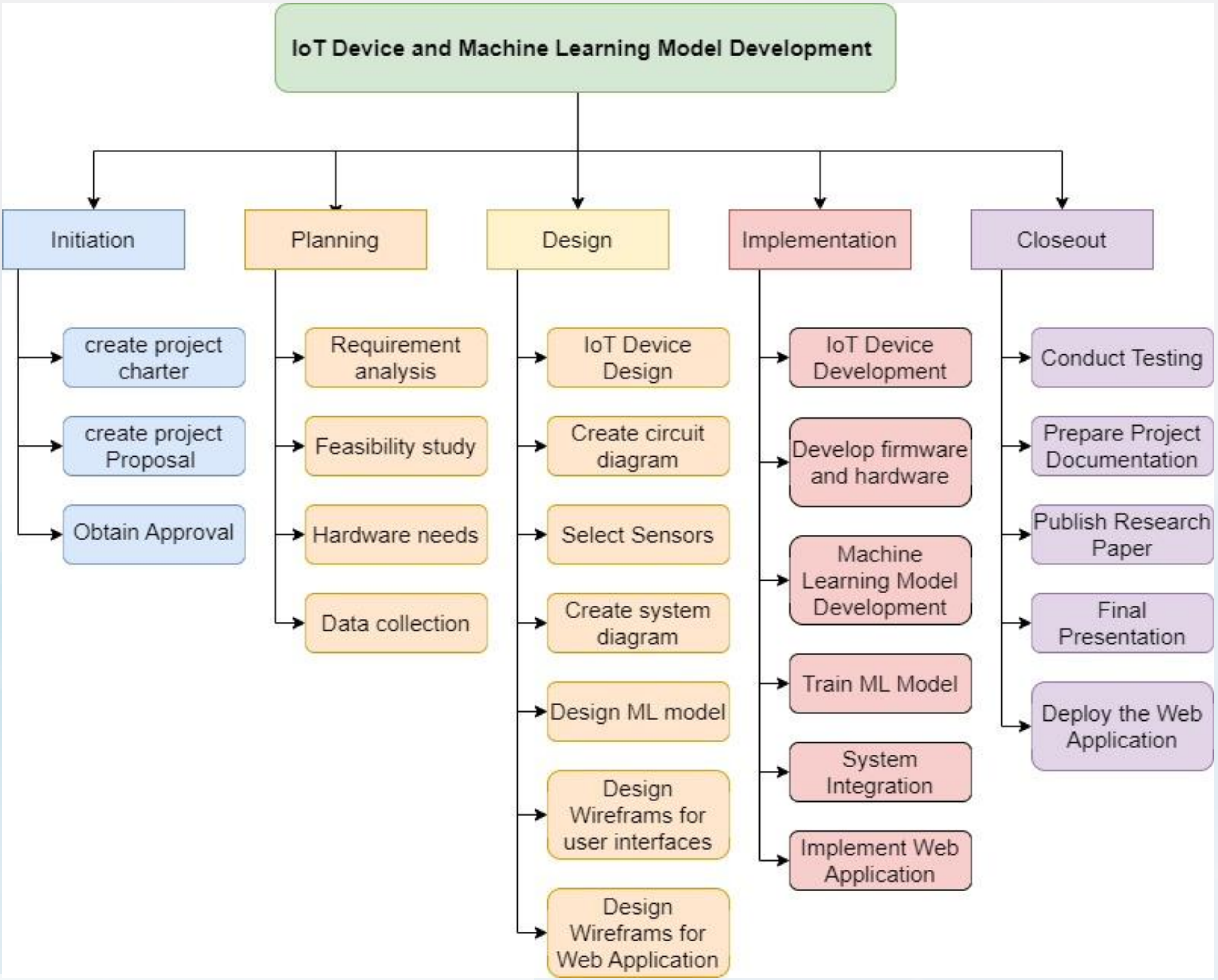
Data Sets Collection for the project is being carried out using the following ways:

- Public data sets
- Previous researches
- Surveys
- **From Agriculture department**

System diagram



Work Breakdown Structure



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IT21186592 | NAJAS MNM.

Specialization : Information Technology

Detecting Tomato Diseases and Recommending Appropriate Treatment

Introduction

- Maintaining healthy tomato plants in greenhouses is crucial for maximizing yield and quality

- This project aims to develop a comprehensive system that leverages image analysis and machine learning to detect tomato diseases and recommend appropriate treatments.

Background

❑ The Impact of Diseases on Tomato Crops:

- Tomato plants are susceptible to diseases that can significantly reduce yield and quality.
- Early and accurate detection is essential for effective disease management.

❑ Challenges in Disease Management :

- Traditional methods rely on manual inspection, Which can take a lot of time and lead to mistakes.
- If you don’t act fast, you can lose a lot of crops and need to use more pesticides.

Research Gap

Existing Products / Research	Predictive Analytics				
	Image Analysis Tools	Manual Inspection	Disease Specific Detection	Automated Treatment Recommendation	Predictive Analytics
Current Methods	✗	✓	✓	✗	✗
Basic Automated Tools	✓	✓	✗	✗	✗
Proposed System	✓	✗	✓	✓	✓

Research Question

How can we develop a decision support system for tomato greenhouses that detects diseases and recommends appropriate treatments based on image analysis and machine learning?

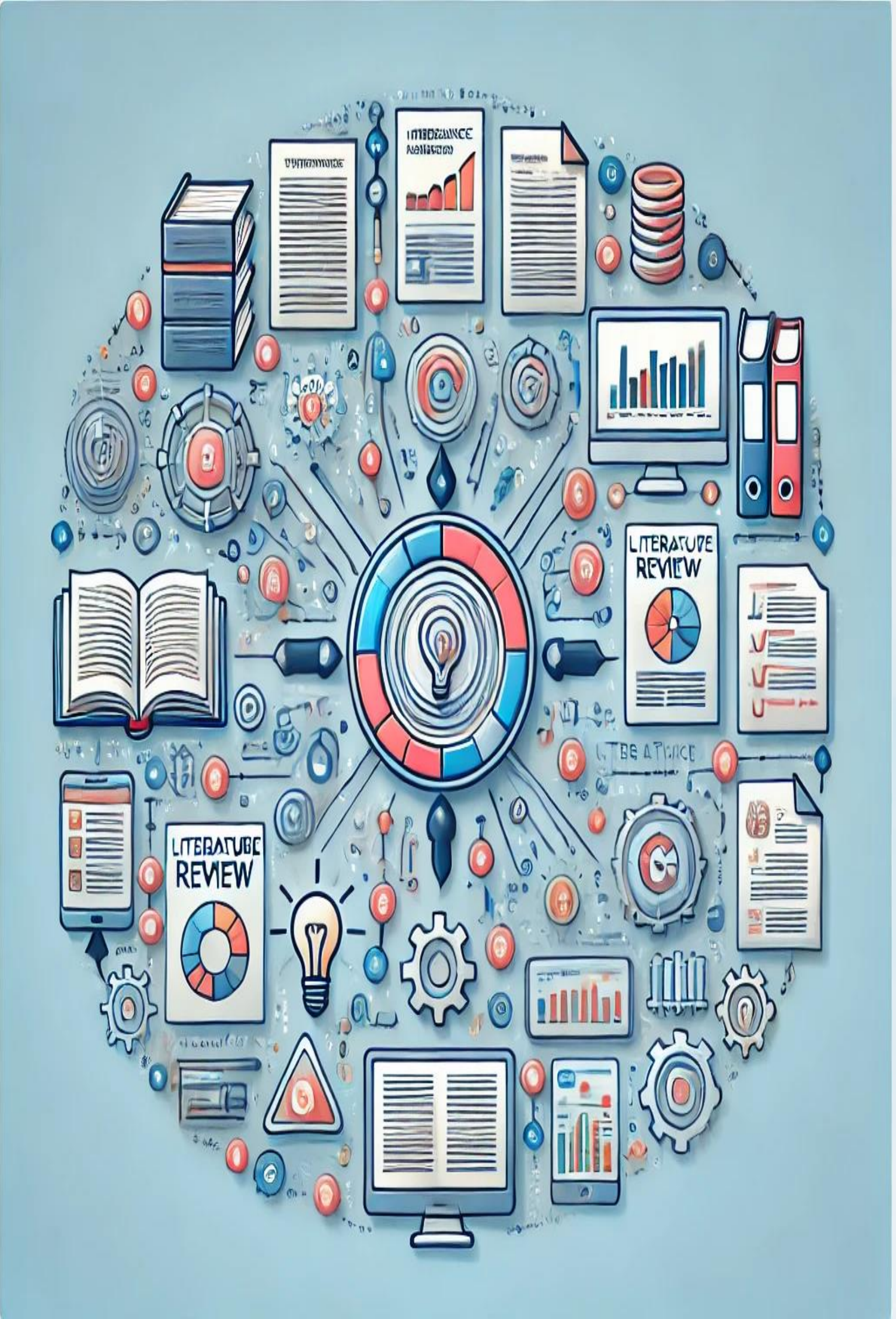
Specific & Sub Objectives

Specific Objective

Develop a comprehensive system to detect tomato diseases and recommend appropriate treatments using image analysis and machine learning.

Sub Objective

- Select data from Kaggle.
- Label the images with corresponding disease types.
- Preprocess the images (resize, normalize, augment) for model training.
- Develop a CNN model architecture suitable for image classification.
- Train the CNN model on the labeled dataset and evaluate its performance.



Literature Review

- Highlights the current state of research and systems in the field.
- Identifies gaps in existing solutions.
- Emphasizes the need for a comprehensive system integrating image analysis, machine learning, and treatment recommendations.

Proposed System Overview

1 **Data Collection**

Gather annotated images of tomato plants from Kaggle.

2 **Image Preprocessing**

Resize, normalize and augment images to prepare for model training.

3 **Model Development**

Design and train a Convolutional Neural Network (CNN) for disease detection.

4 **Treatment Recommendation**

Develop a system to recommend treatments based on detected diseases.

5 **Centralized Dashboard**

visualization of disease detection and treatment recommendations.

Methodology

- **Data Collection and Labeling**: Select and annotate images from Kaggle.
- **Image Preprocessing**: Resize, normalize, and augment images.
- **CNN Model Development**: Design and train a CNN model for disease classification.
- **Performance Evaluation**: Evaluate the model's performance using metrics such as accuracy, precision, and recall.
- **Implementation of Recommendation System**: Provide treatment recommendations based on disease detection.

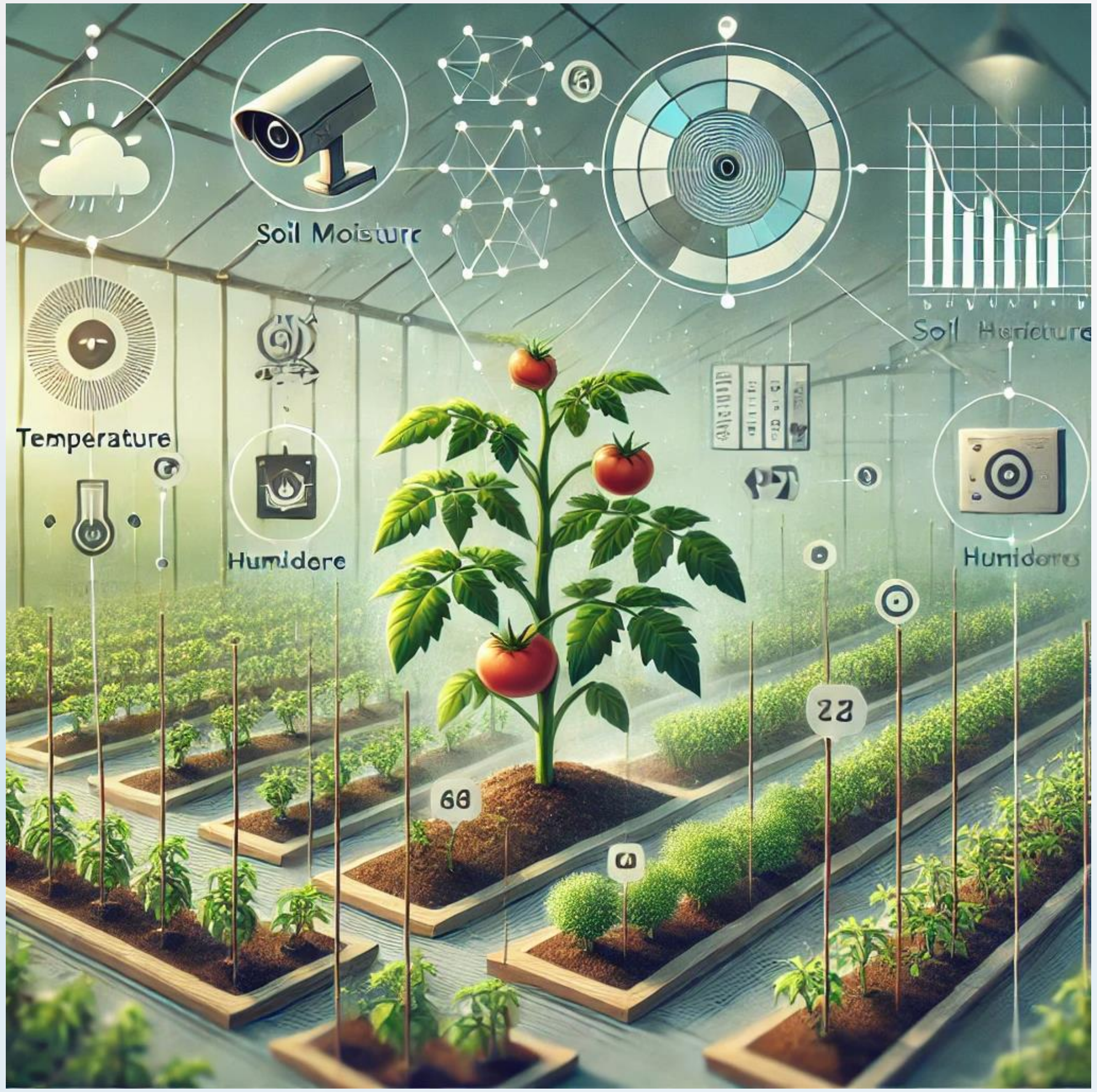
Technologies and Techniques

- Python, TensorFlow, Keras.
- Image preprocessing techniques.
- CNN model design and training.
- Data visualization tools.

Data Collection

Data Collection :

- Kaggle datasets.
- Annotated images of tomato plants with various diseases.
- Data cleaning and preprocessing.



Requirements

System requirements

- High-quality annotated image datasets.
- image preprocessing pipeline.
- Efficient CNN model for disease detection.
- Treatment recommendation algorithms.
- User-friendly dashboard for real-time alerts and recommendations.

Non-functional Requirements

- Performance
- Reliability
- Scalability
- Security
- Usability
- Maintainability
- Accuracy

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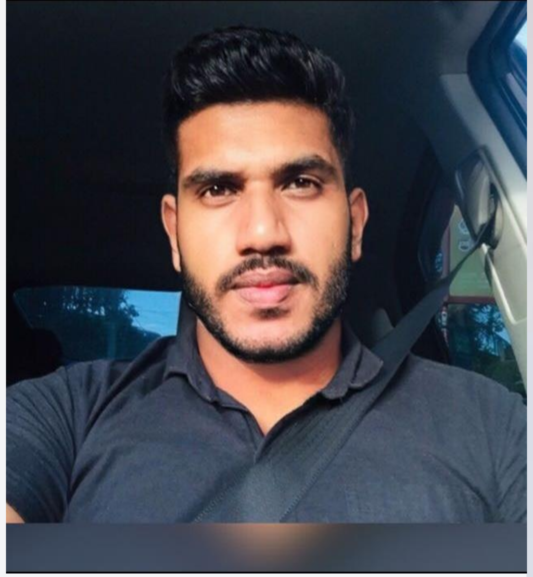


IT21231414 | JAYANETHTHI I H N S

Specialization : Information Technology

Introduction

Background

❑ The Forecasting tomato harvest dates :

- The growth and development of tomato plants are highly sensitive to temperature. Optimal temperatures range between 20°C to 25°C. Both high and low temperatures can slow growth, affect pollination, and delay fruit ripening. Heat stress, particularly during flowering and fruit set, can significantly impact yield and quality.[1]

- The timing of planting relative to the local climate and season affects the growing conditions experienced by the plants, thus influencing the harvest date.[2]

- Practices such as pruning, staking, and mulching can influence plant microclimate, disease incidence, and overall plant health, thereby affecting maturation rates..[3]

Research Gap Introduction

Existing Products / Research	Features				
	Fruit set, ripening speed, leaf area index, root development	Soil moisture, nutrient availability, soil microbiome composition	Genotypic variation, phenotypic traits, cultivar-specific responses	Salinity, heavy metals, waterlogging, drought stress	Pest pressure, disease incidence, environmental stressors
Comprehensive Characterization of Plant Physiological Traits.	✓	✗	✗	✗	✗
Temporal Dynamics of Soil-Plant Interactions	✗	✓	✗	✗	✗
Underutilization of Genotypic and Phenotypic Data	✗	✗	✓	✗	✗
Role of Abiotic Stress Factors Beyond Temperature	✗	✗	✗	✓	✗
Interaction Between Abiotic and Biotic Factors	✗	✗	✗	✗	✓

Research Question

How can environmental and agronomic factors be integrated into a predictive model to accurately forecast the optimal harvest dates for different tomato varieties?

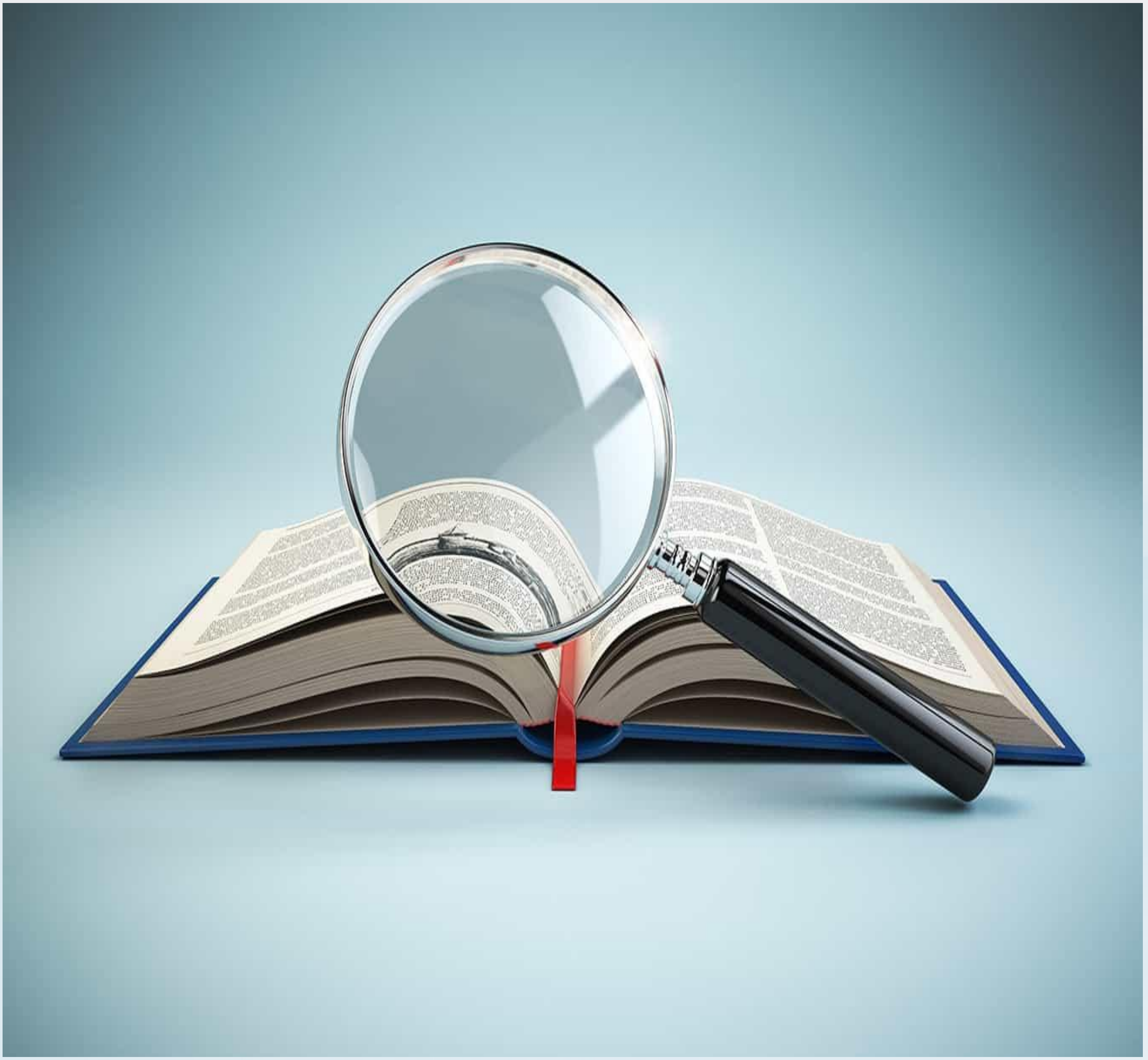
Specific & Sub Objectives

Specific Objective

To develop and validate a machine learning-based model that accurately predicts the optimal harvest dates for tomatoes by analyzing key environmental factors (temperature, humidity, light) and agronomic practices (soil fertility, irrigation, and planting schedules).

Sub Objective

- Develop a predictive model using machine learning algorithms
- Identify and engineer relevant features from the collected data
- Design and implement a decision support tool that integrates the predictive model



Literature Review

Tomatoes (Solanum lycopersicum) are a globally important crop, both economically and nutritionally. The timing of tomato harvest significantly influences fruit quality, marketability, and post-harvest losses. Traditional methods for determining harvest readiness often rely on visual inspection and subjective judgment, leading to inconsistencies and potential quality issues (Hewett, 2006). This variability has prompted the development of more objective and reliable methods, including predictive models, to forecast optimal harvest dates.

Methodology

Technologies

- IoT Devices
- MQTT Services
- Firebase/ MongoDB
- Python
- Node
- Intellij Idea

Techniques

1. Real-time data collection and analysis
2. Machine Learning for prediction models

Algorithms

- **Machine Learning Models**: Regression algorithms for predicting schedule
- **Time Series Analysis**: ARIMA or LSTM for predicting environmental conditions

Completion of the project

Data Collection for the project is being carried out using the following ways:

- Public data sets
- Previous researches
- Surveys
- From Agriculture department

Requirements

System requirements

- Data Processing and Storage
- Data Processing and Analytics
- Data Collection Devices
- Real-Time Alerts and Notifications
- Temperature Control

Non-functional requirements

- Performance
- Reliability
- Scalability
- Security
- Usability
- Maintainability
- Accuracy

References

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Thank You!