A Web-Based Application for Monitoring Soil Environmental Conditions

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Abstract— This project presents a web-based application designed for real-time monitoring of soil environmental conditions in agricultural fields, using IoT sensors. The application collects data from various sensors that measure key parameters such as humidity, temperature, pH, light intensity, water level, and electrical conductivity. Users can visualize the data in real-time through an intuitive graphical interface and receive alerts when any parameter exceeds pre-set thresholds. Additionally, the application generates detailed reports that aid in informed decision-making for agricultural management, thereby improving the efficiency and sustainability of farming processes. The main objective is to provide farmers with precise control over soil conditions to optimize resource usage and enhance crop productivity.

Keywords: Soil monitoring, environmental conditions, web application, IoT, agriculture, real-time data, sensors, precision farming, data visualization, alerts, sustainability

I. Introduction

Precision agriculture is a field that utilizes advanced technologies such as IoT sensors to monitor and manage the conditions of crops and soil in real-time. This enables more efficient resource management and improves crop productivity. However, many current solutions lack an integrated platform that combines monitoring of multiple environmental parameters and offers decision support tools.

The goal of this project is to develop a web platform that integrates IoT sensors to monitor key soil and climate parameters, such as moisture, temperature, pH, and water levels. The system also includes an automated irrigation management module, real-time alerts, and tools for crop planning. With this platform, farmers will be able to make informed decisions about resource usage, improving the efficiency and sustainability of their agricultural practices

II. Related Work

In the current literature, several initiatives related to environmental condition monitoring in agriculture exist. For instance, Brown et al. [1] developed a sensor-based system to measure soil moisture and improve irrigation efficiency. Similarly, Pérez et al. [2] implemented a similar solution that integrates sensors to measure soil temperature and pH, using the collected data to optimize fertilization.

However, despite these advances, most existing systems are limited to measuring individual parameters without providing an integrated approach. Additionally, few systems offer the capability to automate irrigation management or integrate climatic conditions into decision-making. Our project aims to overcome these limitations by providing a web platform that collects data from multiple sensors, processes the information, and offers alerts and planning tools to optimize agricultural management.

III. SYSTEM DESING AND METHODOLOGY

A. System Architecture

The architecture diagram is crucial for understanding the overall structure of the system. It shows how different components of the system (sensors, server, database, and user interface) interact with each other. IoT sensors collect data from the cultivation environment (temperature, humidity, pH, etc.), which is then sent to a central server for processing and storage in a database. Users can access the platform via a web interface to visualize and manage the data.

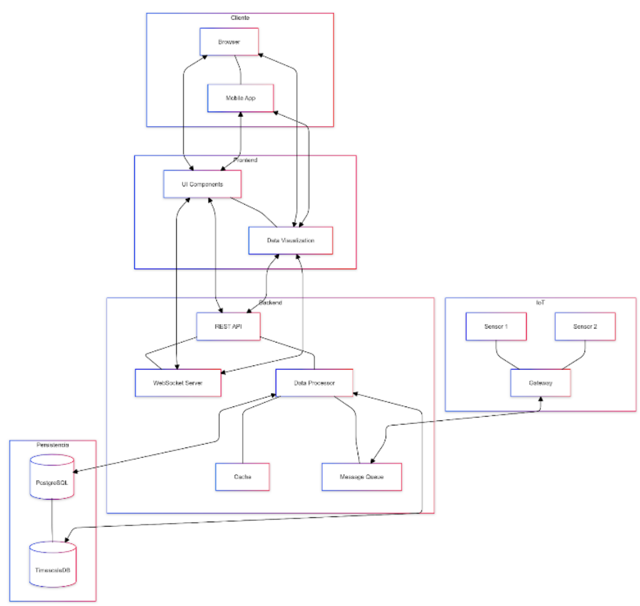

Fig. 1 System architecture diagram

Fig. 1 depicts the system architecture diagram, demonstrating how sensors collect data, transmit it to the server for processing, and store it in the database. The user interface provides real-time data visualization, enabling users to monitor and manage soil conditions effectively.

B. Data Collection and Processing

Data collection is done through IoT sensors placed in the field, which measure important parameters such as soil humidity, temperature, pH, gas concentration, and others. This data is sent to the server, where it is processed and analyzed to generate reports and recommendations that help users make decisions about crop management.

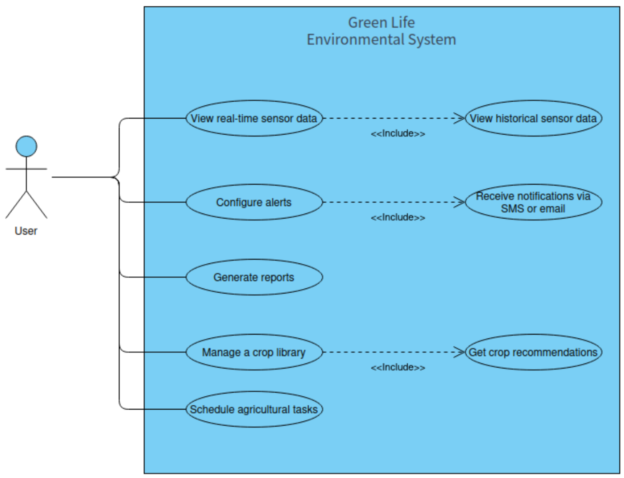

Fig. 2 Use case diagram

Fig. 2 illustrates the use case diagram, highlighting how users interact with the system to access processed data. Farmers can view real-time soil condition information, receive alerts about adverse conditions, and adjust parameters such as irrigation and fertilization based on system recommendations.

C. User Interface

The user interface is designed to be intuitive and user-friendly. Upon opening the app, users are greeted with a home screen that provides access to various features of the platform. The home screen includes options for logging in, user registration, and quick links to key sections such as real-time data visualization and crop management, as shown in Fig. 3.

Fig 3. Home screen

1) *Login Screen:* The login screen allows users to securely enter their credentials to access the platform. This form includes fields for username and password, with options for password recovery or new user registration. Once logged in, users can access their personalized dashboard to monitor crop conditions and receive alerts, as showing in Fig. 4.

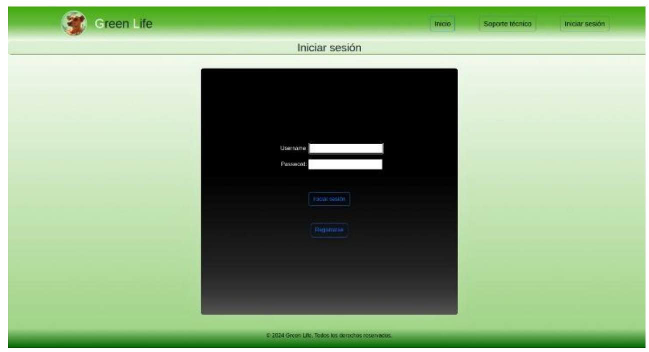

Fig. 4 Login screen

2) *Technical Support Form:* In addition to the main functionalities, the platform includes a technical support form that allows users to report any issues or request assistance. This form captures essential information such as the user's contact details, the issue description, and urgency level. Submitting this form ensures that users receive prompt support, as shown in Fig. 5.

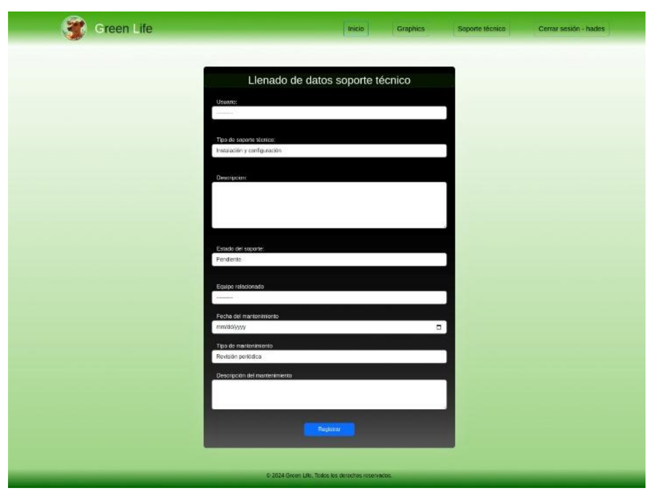

Fig. 5 Technical Support Form

IV. Results and Discussion

A. Real-Time Data Visualization

One of the key features of the platform is the real-time data visualization. Users can view various parameters from both the soil and water through interactive graphs displayed on the dashboard. This functionality allows users to maintain a clear and up-to-date view of their crops' conditions. Real-time visualization helps farmers quickly identify potential issues, such as a drop in moisture or an unexpected rise in temperature, and take immediate corrective actions.

The dashboards display critical data from the soil and water environments. The soil dashboard presents parameters such as soil temperature, humidity, pH, light intensity, and gas concentration, while the water dashboard shows water levels, rainfall presence, temperature, pH, and conductivity. These dashboards provide a comprehensive overview of the environmental conditions, enabling farmers to make informed decisions regarding irrigation, crop management, and environmental monitoring.

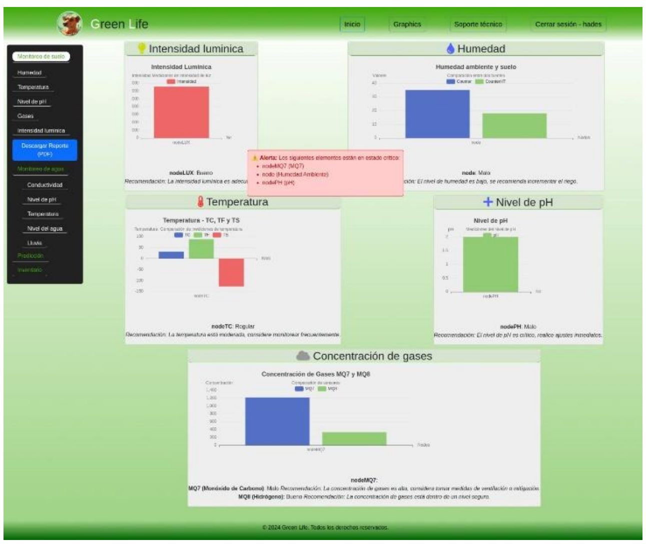

Fig. 6 Soil dashboard

Fig. 6 shows the soil dashboard, which displays essential soil parameters in real time, including temperature, humidity, pH, and gas concentrations. The interactive graphs allow users to track these values easily and monitor trends over time.

Fig. 7 Water dashboard

Fig. 7 illustrates the water control panel, designed to provide key information on water levels, rainfall, temperature, pH, and electrical conductivity. This panel enables farmers to efficiently manage irrigation and monitor water quality, facilitating informed decision-making in real time.

B. Predictive AI Model

The integration of the predictive AI model is one of the most powerful features of the platform. The AI analyzes historical and real-time data from sensors to make predictions about future soil and water conditions, enabling farmers to optimize their activities. The predictions cover several crucial areas:

- Irrigation: The AI predicts the optimal irrigation schedule based on factors such as soil moisture, weather forecasts, and crop needs. By anticipating the water requirements for the crops, the system helps ensure efficient use of water resources.
- Fertilization and Inputs: The platform can predict the required inputs (such as fertilizers) based on soil nutrient levels and the crops' growth stages. This enables farmers to make timely decisions about fertilization and other agricultural inputs.
- Planting: The predictive model also provides recommendations on the best time for planting crops based on factors like soil conditions, temperature, and expected rainfall.
- Harvesting: The system predicts the optimal harvest time by analyzing crop growth patterns, weather conditions, and other relevant factors, helping farmers maximize yield and quality.

This predictive capability helps farmers plan and manage their activities more efficiently, reducing waste and increasing crop productivity.

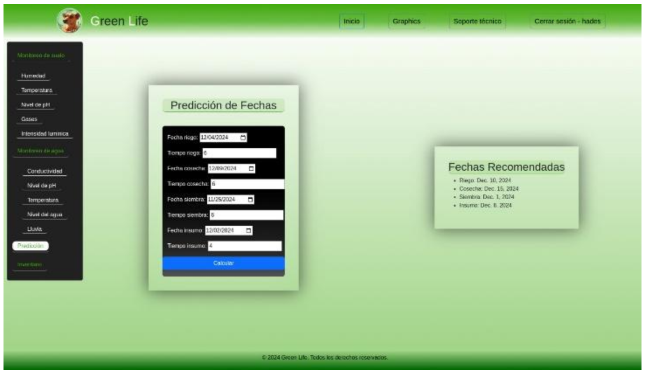

Fig. 8 AI Predictions

Fig. 8 displays the AI-generated predictions for various agricultural activities, such as irrigation schedules, fertilization requirements, optimal planting periods, and harvest forecasts. These predictions provide actionable insights to optimize farming operations.

V. CONCLUSION

This paper presents a comprehensive precision agriculture platform that combines real-time monitoring of soil and water conditions with a predictive model powered by artificial intelligence. The integration of IoT sensors allows for continuous data collection, while the predictive model offers precise recommendations for irrigation management, input application, planting, and harvesting. This approach provides farmers with an effective tool to optimize resources, increase productivity, and make more informed and sustainable decisions. With an alert system and user-friendly interface, the platform contributes to operational efficiency and resource waste reduction. In the future, the platform is expected to evolve with additional capabilities, such as the inclusion of new sensors and more advanced algorithms, to continuously adapt to the ever-changing needs of modern agriculture.

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