Smart Agriculture Management Platform for Illinois Farmers

Contents

1 Summary

The Smart Agriculture Management Platform is an innovative web-based solution designed specifically for Illinois farmers to enhance crop management through advanced data integration and analysis. The Smart Agriculture Management Platform consolidates real-time weather data, soil information, and on-farm sensor readings into a single, user-friendly dashboard. The platform utilizes trusted data sources like the NOAA, USDA, and NASA, the system collects and analyzes critical agricultural metrics, that include, but are not limited to, Illinois-specific weather conditions, soil moisture levels, satellite imagery, and temperature variations. Using this data, the application will provide useful insights and tailored recommendations to optimize crop management and improve yield. Through data-driven insights, the platform offers tailored recommendations to help users optimize crop management practices and improve yield outcomes. By harnessing advanced analytics, our solution not only enhances agricultural productivity but also promotes sustainable farming practices, empowering users to make informed decisions for long-term success and lessening the gap between smaller farmers and corporations.

2 Description

The goal of this project is to empower Illinois-based farmers, especially those operating small to medium-sized farms, with advanced, data-driven decision support tools that were once available only through expensive, proprietary systems. Farmers often struggle with:

- Unpredictable weather patterns
- Limited real-time insights
- Resource mismanagement

Without accessible and cost-effective solutions, these farms often find it difficult to compete with larger agricultural operations. The platform addresses these challenges by offering precise, real-time insights to:

- Optimize water and nutrient management
- Reduce waste
- Mitigate crop disease risks

By providing free access to advanced analytics, real-time monitoring, and personalized recommendations, the platform improves crop yields, lowers production costs, and promotes environmental sustainability.

3 Creative Component

The platform features a comprehensive farm management dashboard that includes:

- **Interactive Map:** Displays real-time farm conditions. Users can zoom in to view specific crop zones, each with its unique soil moisture, precipitation, and nutrient requirements.
- **Data Visualization Charts:** Show trends in soil moisture, nutrient levels, crop health, and growth stage. Automated recommendations and alerts are built into these charts.

This user-friendly interface helps farmers track crop health, make data-supported decisions, and identify areas requiring additional attention or resources.

4 Usefulness and Basic Functions

The Smart Agriculture Management Platform for Illinois Farmers is extremely useful because it provides farmers with a centralized, data-driven system to optimize their resource management and crop production. Key functions include:

- Aggregation of real-time weather data, soil moisture information, satellite imagery, and on-farm sensor data.
- Farm plot management (add, update, delete records).
- Crop recommendation search and AI-driven yield predictions.
- Data visualization of current conditions and historical trends.
- Real-time alerts for adverse weather events such as frost or heat waves.
- Advanced features like an interactive crop-growth heatmap and machine learning-based yield predictions.

5 Comparison with Existing Applications

While similar solutions exist (e.g., John Deere Operations Center, Climate FieldView, Microsoft FarmBeats), these platforms are often:

- Proprietary and tied to specific equipment ecosystems
- Expensive, with high subscription fees

In contrast, our open-source platform emphasizes:

- Customizability
- Ease of use
- Broad accessibility for small and medium-sized farms

This allows us to integrate multiple public datasets with on-farm sensor data to deliver useful insights.

6 Realness

This section highlights additional datasets integrated into the platform, demonstrating its comprehensive, data-driven approach to supporting Illinois agriculture.

6.1 SoilGrids Data

SoilGrids dataset:`https://www.isric.org/explore/soilgrids/faq-soilgrids`. This dataset contains common soil chemical and physical properties and is part of a global digital soil mapping system. It uses global soil profile data and environmental covariates to model soil properties at a 250 m spatial resolution across six standard depths. Global models are calibrated with all available observations and covariates, ensuring consistent predictions worldwide. SoilGrids consists of three main elements:

- A master VRT file (defining the raster dimensions: 512 pixels × 512 pixels)
- An OVR file that facilitates rapid visualization
- A directory containing GeoTIFF tiles

Each file follows a naming convention with three parts (property, depthInterval, and quantile) separated by underscores. For example, `cfvo_5-15cm_q05.vrt` is the master file for predicting the 5% quantile of coarse fragments in the soil layer from 5 cm to 15 cm deep.

Mapped Soil Properties

Name	Description	Mapped Units	Conversion Factor	Conventional Units
bdod	Bulk density of the fine earth fraction	cg/cm^3	100	kg/dm^3
cec	Cation Exchange Capacity of the soil	mmol(c)/kg	10	cmol(c)/kg
cfvo	Volumetric fraction of coarse fragments	cm^3/dm^3 (vol‰)	10	$cm^3/100cm^3$ (vol%)
clay	Proportion of clay particles (<0.002 mm) in fine earth	g/kg	10	g/100g (%)
nitrogen	Total nitrogen (N)	cg/kg	100	g/kg
phh2o	Soil pH	pHx10	10	pH
sand	Proportion of sand particles in fine earth	g/kg	10	g/100g (%)
silt	Proportion of silt particles in fine earth	g/kg	10	g/100g (%)
soc	Soil organic carbon content in fine earth	dg/kg	10	g/kg
ocd	Organic carbon density	hg/m^3	10	kg/m^3
ocs	Organic carbon stocks	t/ha	10	kg/m^2

6.2 NASA Soil Moisture and Crop Condition

Data derived from NASA (see `https://nassgeo.csiss.gmu.edu/CropCASMA/`) provides weekly soil moisture (SM) levels for Illinois. For example, a sample file named `SMAP-9KM-WEEKLY-TOP_2025_01_2024.12.30_2025.01.06_AVERAGE` includes the SM level and its geographical distribution over the period 2024/12/30 to 2025/01/06. The droughtiness level data is organized as a 15 × 4 matrix, where:

- **Category:** SM level category
- **Pixels:** Geographical coordinates (longitude, latitude)
- **Acreage:** Cumulative area represented by the pixels (in real distance)
- **Percentage:** Proportion of the cumulative area in Illinois

The dataset is provided in CSV format.

6.3 Daily Temperature and Precipitation Analysis

Data from the National Oceanic and Atmospheric Administration is available at `https://www.weather.gov/ilx/illinois-daily`. This dataset contains:

- **Temperature Data:** 96 rows and 3 columns (Location, High, Low)
- **Precipitation Data:** 181 rows and 4 columns (Location, Pcpn [precipitation], Snow, Depth)

These precise measurements are crucial for agricultural planning, water management, and other applications.

6.4 USDA/NASS QuickStats Ad-hoc Query Tool

This USDA dataset offers extensive details regarding irrigation practices in Illinois agriculture. The CSV file (dimensions 13×445) includes variables such as:

- **Program:** Indicates data gathered via the census
- **Year:** 2023
- **Period:** Annual data collection
- **Geo Level:** Aggregated by state (with Illinois listed under both State and State ANSI codes)
- **Watershed Code:** A unique identifier for each watershed area (approximate placeholder)
- **Commodity:** Categorizes agricultural products (e.g., corn)
- **Data Item:** Provides specifics such as crop type, irrigation practices, and measurements (in acres-feet)
- **Domain:** Refers to the method or scope of data collection (e.g., irrigation methods)

An accompanying table further details:

- **Domain Category:** E.g., pressure systems in irrigation
- **Value:** Numerical data for water usage or area coverage
- **CV (%):** Coefficient of Variation, indicating reliability and consistency

Together, these variables offer an in-depth view of water resource management in agriculture, supporting informed decision-making and sustainable practices.

7 Functionality

The platform offers CRUD operations (Create, Read, Update, Delete), a keyword search feature, and an interactive dashboard, enabling effective interaction with farm data.

7.1 Key Functionalities

- **Farm Management:** Create, update, and delete farm plots with details such as crop type, planting dates, and locations.
- **Crop Insights:** Search for crop recommendations and receive AI-driven yield predictions.
- **Interactive Map:** View real-time attributes (soil conditions, nutrient levels, temperature, precipitation) on a zoomable map.

- **Data Visualization:** Display real-time weather conditions, soil moisture levels, crop health, nutrient levels, growth stage, and crop-growth heatmaps using data from NOAA, USDA, and NASA.
- **Alerts and Notifications:** Automated alerts for adverse weather events (e.g., frost, drought, storms).

7.2 Database and Backend Features

- **CRUD Operations:** Manage farm plots, crop records, and yield forecasts.
- **Keyword Search:** Find specific records such as crop types or weather trends.
- **Stored Procedures:** Automate tasks like generating monthly farm performance reports.
- **Triggers:** Automatically log critical events (e.g., weather warnings, soil condition changes).
- **Transactions:** Ensure data consistency during bulk updates.

8 Low Fidelity UI Mockup

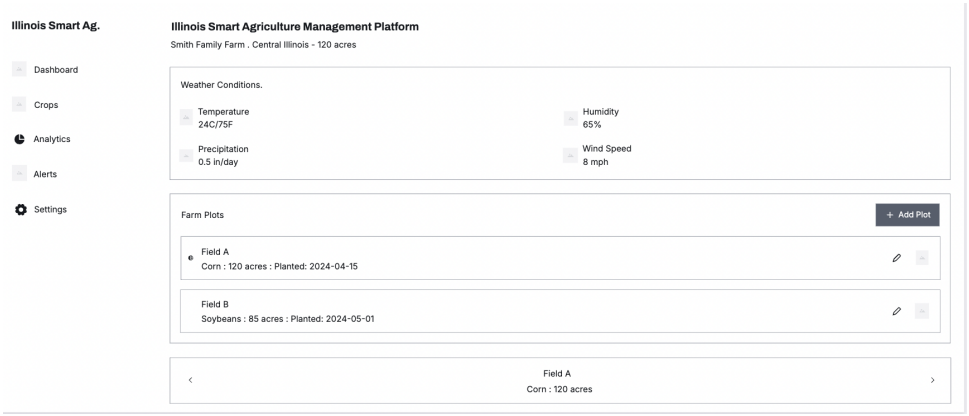

Figure 1: Screen 1

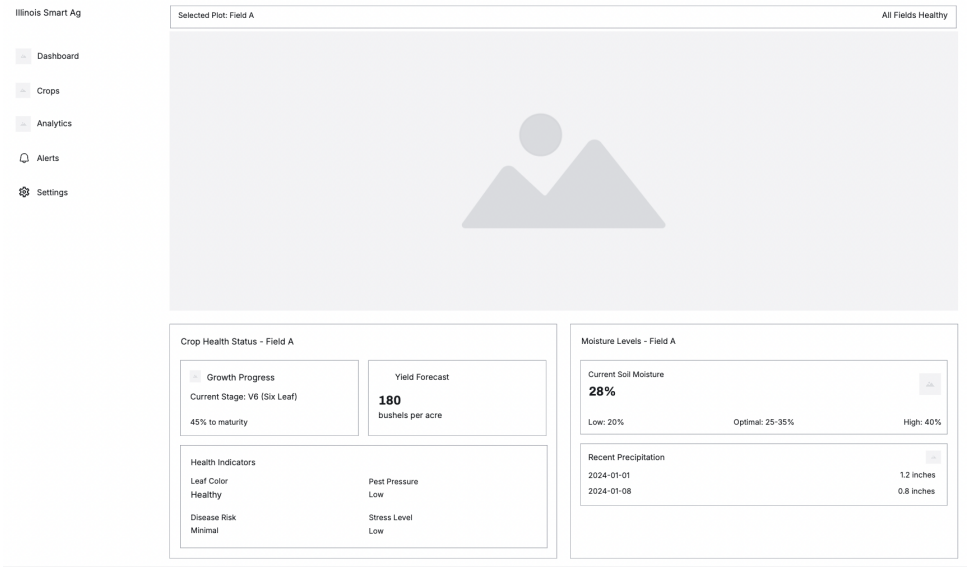

Figure 2: Screen 2

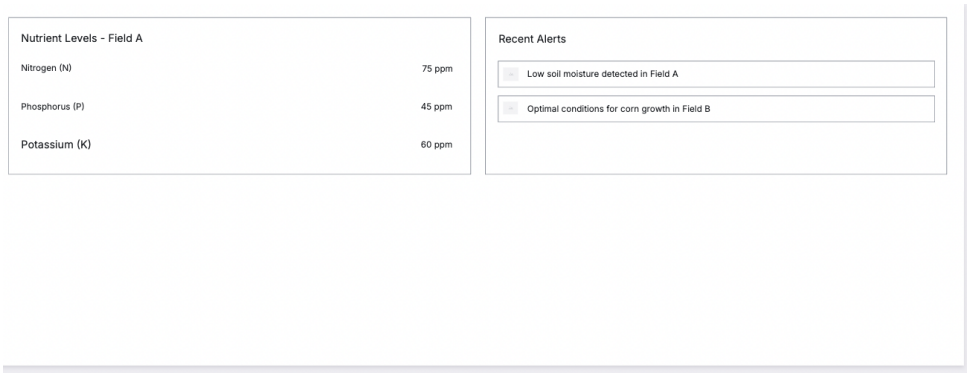

Figure 3: Screen 3

9 Project Work Distribution

Task	**Assignees**
Data Preprocessing	Rayva, Andrew
Database Integration	Chandani, Geetha
Machine Learning Prediction	Rayva, Chandani
SQL Database Management	Andrew, Geetha
Frontend Backend Integration	Rayva, Andrew
UI	Geetha, Rayva

Table 1: Project Work Distribution