SMART INDIA HACKATHON 2025

- **Problem Statement ID –** 25099
- **Problem Statement Title-** AI-powered monitoring of crop health, soil condition, and pest risks using multispectral/hyperspectral imaging and sensor data.
- **Theme-** Agriculture, FoodTech and Rural Development
- **PS Category-** Software
- **Team ID-** 102558
- **Team Name (Registered on portal) -** _FarmAssist_

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PROPOSED SOLUTION

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We present an AI-powered agricultural platform that fuses hyperspectral imaging, IoT sensor data, and deep learning to provide real-time insights on crop health, soil quality, and pest risks. Built with Python, MATLAB, Next.js, and Firebase, it delivers spectral maps, soil summaries, and predictive alerts through an interactive dashboard. This unified system enables proactive crop management, enhancing productivity, reducing losses, and promoting sustainable farming practices.

KEY FEATURES

01 AI-Powered Analysis
Uses CNN and LSTM models to interpret fused hyperspectral and sensor data with greater accuracy.

02 Interactive Dashboard
Offers health maps, soil summaries, and charts that are easy to navigate for farmers and agronomists.

03 Zone-Specific Guidance
Delivers customized recommendations for each section of a field, improving efficiency and productivity.

04 Predictive Trend Insights
Tracks crop growth, soil shifts, and risk zones with predictive alerts for timely interventions.

INNOVATION AND UNIQUENESS

01 Fusion of Data Sources
Combines hyperspectral imaging with IoT sensor data for richer and more reliable insights.

02 Farmer-First Design
Simplifies complex analytics into actionable insights without overwhelming users with technical details.

03 Continuous Learning Models
Adapts over time to local conditions, improving prediction accuracy with every season.

04 Proactive Crop Management
InteTransforms farming from reactive problem-solving to proactive planning for higher yields and sustainability.

HOW IT ADDRESSES THE PROBLEM

01 Unified Field Monitoring
Integrates satellite imagery and ground sensors to give farmers a complete, real-time view of their fields.

02 Early Stress Detection
Identifies signs of crop stress, pests, and diseases before they become visible, enabling preventive actions.

03 Data-Driven Farming
Provides precise recommendations that help optimize irrigation, fertilization, and pest control decisions.

04 Reduced Manual Effort
Automates data gathering and analysis, saving time and resources compared to traditional scouting.

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TECHNICAL APPROACH

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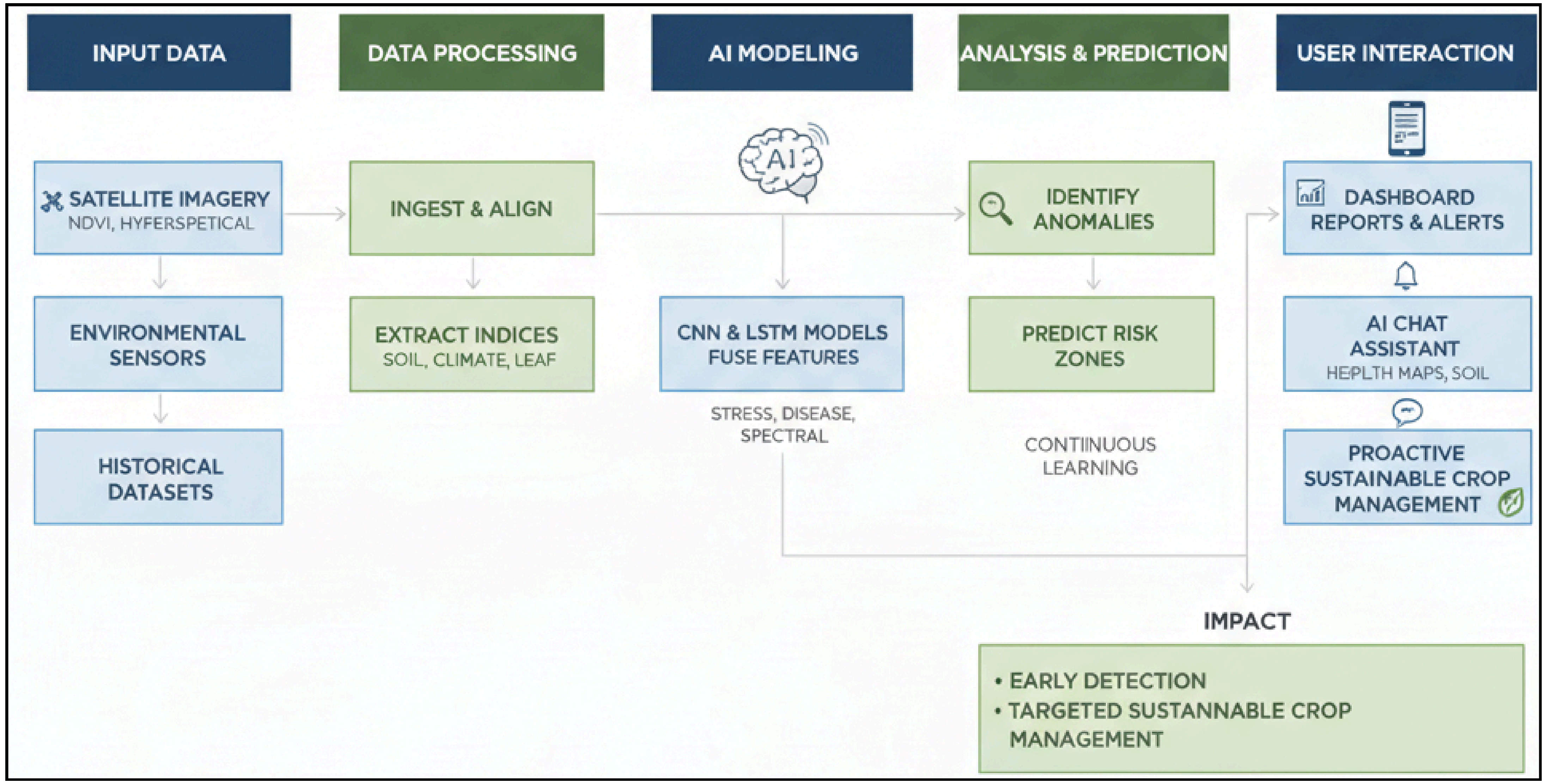
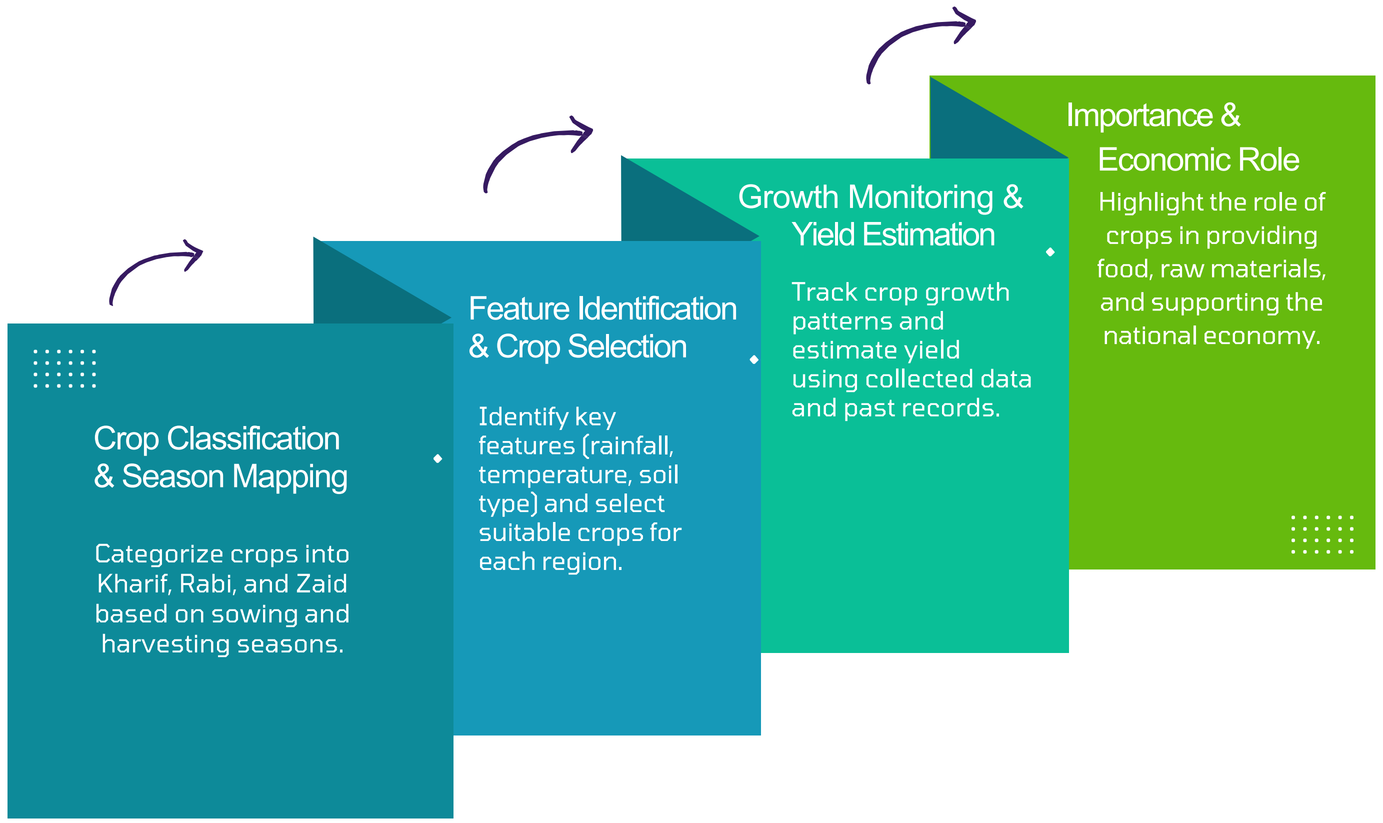
Digital Crop Analysis Workflow



Precision farming workflow



Programming Languages:

Python and MATLAB → For ML model development & preprocessing

TypeScript → For frontend development

Frameworks & Libraries:

Next.js & React → Scalable frontend framework & UI components

Tailwind CSS & Radix UI → Styling and accessible UI primitives

Recharts → Data visualization & analytics

MATLAB (Hyperspectral Imaging, Image Processing, Deep Learning Toolbox) → Spectral data analysis & model training

PyTorch → ML/DL model training & deployment

Firebase - For data storage

TypeScript TS Next.js Next.js RADIX UI Tailwind CSS Recharts MATLAB TensorFlow PyTorch

Crop Management Workflow

Agricultural data is vast and complex. Our system streamlines the process, making crop insights faster, reliable, and farmer-friendly. Its advantages are:

Automated Preprocessing: Cleans and structures raw data for accurate results.
Scalable Handling: Manages large datasets from sensors and satellites with ease.
Smart Predictions: Detects crop stress, pests, and yield risks early.
Interactive Visualization: Provides clear maps, alerts, and soil condition summaries.
Optimized Workflow: Delivers faster, reliable insights for better farm decisions.

FEASIBILITY AND VIABILITY

CHALLENGES AND RISKS

Alignment & Synchronization
GPS errors and time mismatch between satellite images and ground sensor readings.

Environmental Factors
Clouds, haze, and poor image quality reduce spectral data reliability.

Crop & Soil Variability
Different crop types, soil conditions, and sensor depths affect model accuracy.

Computational & Expertise Limits
Deep learning models need high compute power and domain knowledge.

STRATEGIES TO OVERCOME CHALLENGES

Data Harmonization
Aggregate small patches and allow tolerance (±2 days, ≤30 m) for accurate alignment.

Quality Control
Apply cloud masks, use quality flags, and collect multi-temporal images to minimize gaps.

Model Customization
Train crop/soil-specific models or generalize with larger, diverse datasets.

Progressive Scaling
Begin with simpler models (RF, SVM) and gradually scale to CNN/LSTM with more resources.

FEASIBILITY

Technical Feasibility

The solution leverages existing tools (MATLAB/HSI Library, Sentinel-2, sensor data) and proven AI models (SVM, CNN, LSTM), making implementation technically achievable.

Operational Feasibility

Field sensors, remote sensing data, and farmer-friendly dashboards ensure smooth adoption, with minimal disruption to existing farming workflows.

Economic Feasibility

Open-source datasets, scalable cloud resources, and gradual AI model upgrades reduce costs, making the solution cost-effective and sustainable for long-term use.

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IMPACT AND BENEFITS

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POTENTIAL IMPACT ON THE TARGET AUDIENCE

Improved Decision-Making
Farmers get clear, data-backed insights to act at the right time.

Risk Reduction
Early detection of crop stress and pests lowers chances of major yield losses.

Resource Optimization
Efficient use of water, fertilizer, and pesticides saves costs and land health.

Higher Yield & Income
Stronger crops and timely interventions boost productivity and profits.

BENEFITS OF THE SOLUTION

01 Innovation in Agriculture
Integrates AI, remote sensing, and IoT to modernize farming practices, paving the way for scalable precision agriculture and long-term resilience.

02 Social Upliftment
Improves quality of life by reducing farm risks, lowering uncertainty, and fostering confidence in adopting modern practices.

03 Environmental Protection
Reduces water wastage, lowers fertilizer runoff, and preserves soil health, contributing to long-term ecological balance.

04 Economic Growth
Boosts farmer profitability by cutting input costs and increasing yields, supporting both individual income and the rural economy.

Benefits

REVENUE MODEL

B2B / Enterprise Licensing
Platform access for agri-input companies, crop insurers, &govt. bodies

Insurance & Risk Assessment
Predictive risk insights for insurers (pricing & claims)

Subscription Plans (SAAS)
Monthly/annual fees for dashboards, reports, & alerts

Freemium → Premium Upsell
Basic features free; premium AI predictions & advice

RESEARCH AND REFERENCES

Live Deployment:

https://crop-health-dashboard-ten.vercel.app/

Demo Video:

https://youtu.be/dOyprAfEQ2k

Source Code:

https://github.com/Akshat-kacodia/SIH_2025_Submission

Research Basis:

- Hyperspectral Imaging for Crop Stress Detection → Used to identify early signs of disease & nutrient deficiency.
  (Mahlein et al., 2018 – Hyperspectral Imaging for Precision Agriculture)
- Soil Moisture & Vegetation Health Link → NDVI & spectral indices influenced by soil moisture levels.
  (Gao et al., 2020 – Monitoring Soil Moisture using Remote Sensing)
- AI for Early Detection & Prediction → CNN, LSTM, SVM effective in classifying stress & spectral patterns.
  (Kamilaris & Prenafeta-Boldú, 2018 – Deep Learning in Agriculture)

Citations:

- Mahlein, A.K. et al. (2018). Hyperspectral Imaging for Precision Agriculture.
- Gao et al. (2020). Monitoring Soil Moisture with Remote Sensing.
- Kamilaris & Prenafeta-Boldú (2018). Deep Learning in Agriculture: A Survey.
- Indian Pines Dataset – Purdue University.
- Victoria Soil Sensor Open Data Portal.