## Paper 1: A Critical Review on Hybrid Framework for Precise Farming with Application of Machine Learning (ML) and Internet of Things (IoT)

* + - **Title**: A Critical Review on Hybrid Framework for Precise Farming with Application of Machine Learning (ML) and Internet of Things (IoT)
    - **Authors**: Ravi Ray Chaudhari, Sanjay Jain, Shashikant Gupta
    - **Year**: 2024
    - **Problem Addressed / Objective**: Addresses inefficiencies in conventional agricul- tural methods causing resource waste, low yields, and environmental impacts; aims to review a hybrid IoT and ML framework for precise farming to enhance output, effi- ciency, and sustainability while meeting the projected 70% increase in food production needed by 2050.
    - **Methodology / System Architecture**: Reviews a hybrid framework where IoT devices collect real-time data (soil quality, weather, crop growth) and transmit it to a

central system; ML algorithms process data to provide insights for optimized irrigation, fertilization, and pest control; scalable for small and large-scale farming.

* + - **Technologies Used**: IoT smart sensors (measuring soil moisture, temperature, solar radiation, etc.), ML algorithms (for data analytics, anomaly detection, yield predic- tion).
    - **Sensors Used**: Smart sensors for soil moisture, temperature, solar radiation, leaf moisture, stem diameter (specific sensors not detailed in snippet).
    - **Communication Protocol**: Not Applicable (snippet does not specify; likely IoT- based wireless protocols).
    - **Deployment Environment**: Applicable to small- and large-scale farming operations; no specific field testing mentioned.
    - **Results / Performance**: Not Applicable (review paper; no empirical results provided in snippet).
    - **Strengths**: Scalable and adaptable framework; reduces pesticide/fertilizer use; en- hances crop yields and sustainability.
    - **Limitations**: Requires further investigation to evaluate efficacy and implementation challenges.
    - **Future Scope**: Evaluate framework efficacy; address implementation difficulties; ex- pand real-world applications.
    - **AI/ML Integration**: ML algorithms for crop growth insights, anomaly detection in soil quality, and optimal planting/harvesting decisions.
    - **Dataset**: Not Applicable (review paper; no specific dataset mentioned).

## Paper 2: Artificial Intelligence and Machine Learning in Soil Analysis for Precision Agriculture: A Review

* + - **Title**: Artificial Intelligence and Machine Learning in Soil Analysis for Precision Agri- culture: A Review
    - **Authors**: Ramijur Rahman, Kulendra Nath Das
    - **Year**: 2025
    - **Problem Addressed / Objective**: Addresses time-consuming, labor-intensive, and costly conventional soil testing; reviews AI and ML applications for efficient, scalable soil analysis to enhance soil health, fertility, and productivity for sustainable agricul- ture.
    - **Methodology / System Architecture**: Reviews AI/ML models (neural networks, support vector machines, deep learning) using data from remote sensing, spectroscopy, and IoT sensors to predict soil parameters (pH, nutrient availability, texture); focuses on data accuracy and scalability.
    - **Technologies Used**: AI/ML models (neural networks, SVM, deep learning), remote sensing, spectroscopy, IoT-based sensors.
    - **Sensors Used**: IoT-based sensors for soil pH, electrical conductivity (EC), organic matter, nutrient levels (N, P, K) (specific sensors not detailed in snippet).
    - **Communication Protocol**: Not Applicable (snippet does not specify; likely IoT- based wireless protocols).
    - **Deployment Environment**: Applicable to various agricultural regions; no specific field testing mentioned.
    - **Results / Performance**: Not Applicable (review paper; no empirical results provided in snippet).
    - **Strengths**: Enhances data accuracy; reduces costs; enables large-scale soil monitoring; supports sustainable nutrient management and yield prediction.
    - **Limitations**: Need for standardized methodologies and farmer-friendly devices; chal- lenges in integrating diverse datasets.
    - **Future Scope**: Enhance AI models with real-time data; develop standardized meth- ods; create accessible devices for farmers.
    - **AI/ML Integration**: Neural networks, SVM, and deep learning for predicting soil parameters and optimizing land use.
    - **Dataset**: Not Applicable (review paper; references diverse datasets from remote sens- ing and IoT).

## Paper 3: AIoT Based Soil Nutrient Analysis and Recommendation Sys- tem for Crops Using Machine Learning

* + - **Title**: AIoT Based Soil Nutrient Analysis and Recommendation System for Crops Using Machine Learning
    - **Authors**: Sehrish Munawar Cheema, Ivan Miguel Pires
    - **Year**: 2025
    - **Problem Addressed / Objective**: Addresses challenges in sustainable agriculture due to climate change, soil erosion, and salinity; develops an AIoT system for soil nutrient analysis and crop recommendation to improve productivity and food security.
    - **Methodology / System Architecture**: IoT sensors collect real-time data (pH, N, P, K, humidity, temperature, rainfall); ML models (Decision Tree with AdaBoost, KNN, DT, RF, SVM) trained on a Kaggle dataset of 22 crops and regional data from Punjab, Pakistan; data compared with cloud repository for crop recommendations via a user-friendly interface.
    - **Technologies Used**: IoT sensors, ML models (Decision Tree with AdaBoost, KNN, DT, RF, SVM), cloud repository, Android application.
    - **Sensors Used**: Sensors for soil pH, nitrogen (N), phosphorus (P), potassium (K), humidity, temperature, rainfall (specific sensors not detailed in snippet).
    - **Communication Protocol**: Not Applicable (snippet does not specify; likely IoT- based wireless protocols to cloud).
    - **Deployment Environment**: Agricultural fields in Punjab, Pakistan; applicable to diverse environmental regions.
    - **Results / Performance**: Decision Tree with AdaBoost achieved 98% accuracy; out- performs KNN, DT, RF, and SVM; enables data-driven crop recommendations.
    - **Strengths**: Non-intrusive; high accuracy; user-friendly interface; supports sustainable agriculture and food security.
    - **Limitations**: Relies on quality of training dataset; specific to 20 major crops in Pun- jab.
    - **Future Scope**: Expand to more crops and regions; improve dataset quality for broader applicability.
    - **AI/ML Integration**: Decision Tree with AdaBoost (98% accuracy), KNN, DT, RF, SVM for crop recommendation based on soil and environmental data.
    - **Dataset**: Kaggle dataset (22 crops); regional dataset for 20 major crops in Punjab, Pakistan.

## Paper 4: Integrating IoT for Soil Monitoring and Hybrid Machine Learn- ing in Predicting Tomato Crop Disease in a Typical South India Station

* + - **Title**: Integrating IoT for Soil Monitoring and Hybrid Machine Learning in Predicting Tomato Crop Disease in a Typical South India Station
    - **Authors**: Gurujukota Ramesh Babu, Mony Gokuldhev, P. S. Brahmanandam
    - **Year**: 2024
    - **Problem Addressed / Objective**: Addresses costly and time-consuming manual tomato crop disease detection; develops an IoT and hybrid ML system for real-time soil monitoring and accurate disease prediction in Anakapalle, South India.
    - **Methodology / System Architecture**: IoT device collects one-minute data on soil humidity, temperature, pH, N, P, K; Kendalls correlations rank parameters; hybrid ML algorithm (Bayesian optimization with KNN) combines KNN, SVM, DT, RF, LR for disease prediction.
    - **Technologies Used**: IoT device, ML algorithms (KNN, SVM, DT, RF, LR), Bayesian optimization with KNN, Kendalls correlation analysis.
    - **Sensors Used**: Sensors for soil humidity, temperature, pH, nitrogen (N), phosphorus (P), potassium (K) (specific sensors not detailed in snippet).
    - **Communication Protocol**: Not Applicable (snippet does not specify; likely IoT- based wireless protocols).
    - **Deployment Environment**: Agricultural fields in Anakapalle, South India; tested during tomato vegetative growth stage.
    - **Results / Performance**: Hybrid algorithm (Bayesian optimization with KNN) achieved 95% accuracy, precision, recall, and 94% F1 score; outperforms individual models (KNN: 80%, SVM: 82%, DT: 77%, RF: 80%, LR: 81%).
    - **Strengths**: High accuracy; rapid and cost-effective disease detection; synergistic IoT and ML integration.
    - **Limitations**: Specific to tomato crops; performance depends on quality of real-time IoT data.
    - **Future Scope**: Expand to other crops; enhance real-time data collection and model robustness.
    - **AI/ML Integration**: Hybrid ML (Bayesian optimization with KNN) for disease pre- diction; individual models (KNN, SVM, DT, RF, LR) evaluated.
    - **Dataset**: Real-time IoT sensor data from Anakapalle fields; no pre-existing dataset mentioned.

## Paper 5: Machine Learning and Deep Learning for Soil Analysis and Classification of Micro and Macro Nutrient Using IoT

* + - **Title**: Machine Learning and Deep Learning for Soil Analysis and Classification of Micro and Macro Nutrient Using IoT
    - **Authors**: Ashish Kumar, Jagdeep Kaur
    - **Year**: 2024
    - **Problem Addressed / Objective**: Addresses inefficiencies in soil nutrient manage- ment; develops an IoT-enabled soil nutrient classification and crop recommendation model (IoTSNA-CR) using ML and DL to optimize fertilizer use and enhance crop production in Maharashtra, India.
    - **Methodology / System Architecture**: IoT sensors collect real-time data (pH, moisture, temperature, water level, NPK, color); data stored in cloud; pre-processed and analyzed using ML (KNN, SVM, RF) and DL (LSTM, ANN) for soil fertility classification and crop recommendation.
    - **Technologies Used**: IoT sensors, cloud computing, ML (KNN, SVM, RF), DL (LSTM, ANN).
    - **Sensors Used**: pH sensor, soil moisture sensor, soil temperature sensor, water level sensor, NPK sensor, color sensor, GPS sensor.
    - **Communication Protocol**: Not Applicable (snippet does not specify; likely IoT- based wireless protocols to cloud).
    - **Deployment Environment**: Agricultural fields in Maharashtra (Marathwada, North Maharashtra, West Maharashtra regions).
    - **Results / Performance**: DL model (LSTM, ANN) achieved 98% accuracy, outper- forming ML models (KNN, SVM, RF); effective for soil fertility classification.
    - **Strengths**: High accuracy; reduces fertilizer use; cost-effective sensory system; sup- ports crop recommendation.
    - **Limitations**: Performance depends on dataset quality; need for well-established real- world datasets.
    - **Future Scope**: Improve dataset quality; enhance DL model performance for broader applications.
    - **AI/ML Integration**: ML (KNN, SVM, RF) and DL (LSTM, ANN) for soil nutrient classification and crop recommendation.
    - **Dataset**: Real-time IoT sensor data (moisture, temperature, NPK, pH, etc.) from Maharashtra fields; includes macro (OC, N, P2O5, K2O) and micro (Fe, Mn, Zn, B, Cu) nutrients.