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KRISHI SAMRIDDHI IOT BASED SMART AGRICULTURE

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ABSTRACT:
Krishi Samruddhi is an innovative, IoT-based smart agriculture system designed to enhance crop productivity through real-time environmental monitoring and intelligent decision-making. This project integrates ESP32 microcontrollers and LoRa RA-02 SX1278 modules to create a low-power, long-range wireless communication network that transmits data without relying on the internet. Sensors including DHT22, soil moisture probes, and an NPK sensor gather vital agricultural parameters such as temperature, humidity, soil moisture, and nutrient levels. The collected data is stored in Firebase and used to power a crop recommendation system based on a Random Forest machine learning model . Additionally, a YOLOv8-based deep learning model is implemented for crop disease detection, particularly focused on rice crops. The combination of IoT, machine learning, and computer vision in Krishi Samruddhi supports precision farming and data-driven agriculture, aiming to empower farmers with actionable insights for better crop management.
Keywords: Intelligent Farming, Internet of Things, ESP32, LoRa Technology, Crop Suggestion, Random Forest Algorithm, NPK Sensor, YOLOv8 for Disease Recognition, Crop Health Monitoring, Firebase.

INTRODUCTION:
Agriculture still forms the backbones of several economies, though farmers themselves go through tough times because of unfavourable weather conditions, inefficient use of resources, and unavailability of timely information. Krishi Samruddhi solves these problems by launching an intelligent, IoT-based agricultural tracking and decision support system that enhances farmers' capacity with real-time information. The project employs ESP32 microcontrollers in conjunction with LoRa RA-02 SX1278 modules to create a low-cost, long-range, and low-power communication network that does not rely on the internet. Through the inclusion of sensors like DHT22 for temperature and humidity, soil moisture sensors, and an NPK sensor for nutrient detection, the system gathers vital information from the farm environment. This information is then stored within Firebase and is processed by using a machine learning-based crop recommending system to help farmers select appropriate crops according to existing soil and weather conditions. In addition to this, there is a computer vision model with YOLOv8 for disease detection within crops—mainly rice—with the help of image processing. Krishi Samruddhi therefore is a complete solution in precision farming utilizing data science, IoT, and AI to increase agricultural productivity as well as make it more sustainable.

LITERATURE :
The convergence of IoT and machine learning in agriculture has made significant progress in recent years due to the demands of precision farming and sustainable production of crops. A number of studies have been made in this field, and they have covered different aspects that include wireless communication technologies to predictive analytics.

LoRa technology, being long-range and low-power, is a strong candidate for distant agricultural use. Dobra et al. (2020) performed LoRa propagation tests in urban and indoor settings to measure signal strength and coverage. The results emphasize the reliability and effectiveness of LoRa even in poor conditions like heavy office buildings, validating its suitability in agricultural applications where internet coverage is sparse [1].

In terms of predictive analytics, Dey et al. (2024) designed a machine learning-driven crop recommendation system for Indian regions. Incorporating variables like NPK values, soil pH, and climatic parameters, their model provides intelligent recommendations based on regional soil and weather patterns. Their study justifies the ability of machine learning algorithms to make optimal crop selection decisions, particularly when there is rich environmental data available [2].

Similarly, Elbasi et al. (2023) compared various machine learning algorithms for crop prediction and determined that ensemble models tended to perform better than conventional classifiers. Their research placed great emphasis on the quality of the dataset and feature selection in obtaining good prediction accuracy. The researchers also asserted that models such as Random Forest offered more robustness and explainability in agricultural applications [4].

Along with prediction and recommendation systems, IoT-based smart agriculture platforms have also been suggested to automate data retrieval and decision-making operations. Mat et al. (2018) used an IoT-based architecture to track soil and environmental conditions in real time. Various sensors were used by their system to gather data and a central interface was given to farmers to enable informed decision-making. The research highlighted the ways in which IoT has the potential to drastically cut down on labor, save resources, and enhance the yield of crops through timely intervention [7].

These research works collectively show the potential of merging IoT with machine learning to revolutionize conventional agricultural practices. They form a robust basis for the creation of end-to-end systems such as Krishi Samruddhi, which utilizes LoRa communication, real-time sensing of the environment, and smart analytics to aid farmers with meaningful insights.

METHODOLOGY:

Krishi Samruddhi uses a multi-layered approach incorporating IoT, machine learning, and computer vision to develop a smart agriculture decision-support system. It is developed on ESP32 microcontrollers interfaced with LoRa RA-02 SX1278 modules, facilitating long-range low-power wireless communication for real-time data transfer without internet connectivity. At the sensing layer, the system gathers critical environmental and soil data through sensors—temperature and humidity through DHT22, capacitive soil water sensors, and an NPK sensor to assess the level of nutrients in soil. The data gathered is transmitted through LoRa to a receiver module and gets stored in Firebase for processing and visualization.

For crop recommendation, a machine learning model is trained on a custom dataset with NPK values, temperature, humidity, and soil moisture information. Different classification algorithms—Random Forest, Support Vector Machine, K-Nearest Neighbours, and Logistic Regression—are tested, and Random Forest is chosen for its better accuracy and resilience. The model suggests appropriate crops based on the prevailing environmental and soil conditions.

In the soil moisture monitoring aspect, the sensors continuously provide readings which are utilized to monitor the moisture content of the field. Through this real-time information, prompt irrigation decisions are made, thus conserving water and avoiding over- and under-watering. Thresholds of moisture are defined in the system to notify users or initiate responses when moisture values dip below acceptable levels.

For disease detection of rice leaf, a deep learning technique is used based on the YOLOv8 object detection model (You Only Look Once, version 8). A training set of images of rice leaves—the images being classified according to widespread diseases—is adopted to train the model. Pictures of rice plants taken via a camera module are inspected by the model in order to detect and identify observable signs of disease. The system can accurately identify diseased plants, enabling early intervention and targeted pesticide application, thereby reducing crop loss.

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This layered and modular methodology ensures that Krishi Samruddhi provides comprehensive support to farmers—from choosing the right crops to maintaining optimal field conditions and managing crop health efficiently.

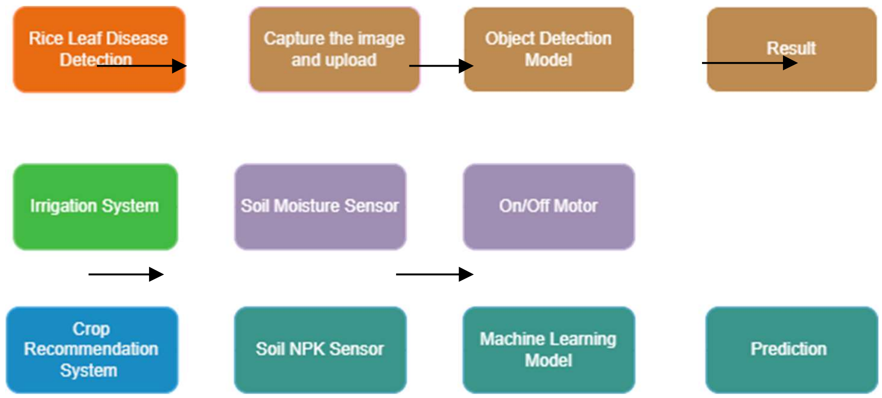

Figure 1 Block Diagram

CIRCUIT DIAGRAM

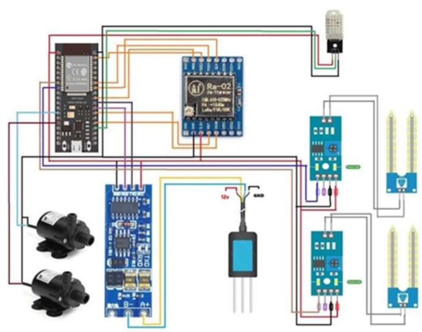

Figure 2 Sender Circuit Diagram

The ESP32 microcontroller is used as the master controller, gathering information from DHT22, Ground water content, and NPK sensors and sending it through the Lora RA-02 module. The SPI protocol is interfaced with the Lora module as follows: COPI (MOSI) to GPIO23, CIPO (MISO), and GPIO19, SCK to GPIO18, CS to GPIO5, RST to GPIO2 and DIO0. The DHT22 is connected to the GPIO15 at its normal living temperature and humidity levels. Water content sensors are connected with GPIO32 and GPIO33 as Analog inputs to measure the dampness of the soil and sends to ESP32. For soil nutrient testing, the NPK sensor Modbus RTU is utilized and communicated on ESP32 using UART2 through PINS GPIO16 (RX) and GPIO17 (TX).

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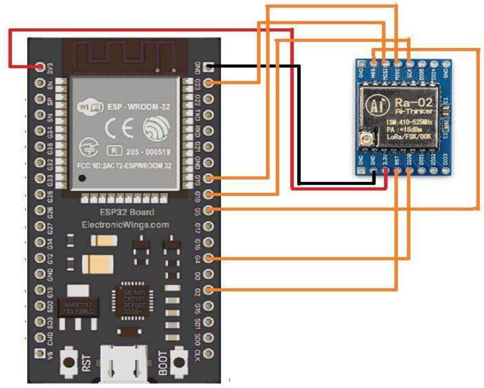

Figure 3 Receiver Circuit Diagram

In the master controller, data via the LORA RA-02 module and delivery data from the online database are fed remotely to the sewer module. The 433 MHz LORA module provides SPI (serial peripheral interface) with the capability of speaking to the ESP32 at long ranges. The 3.3 V service pen is from ESP32 to the LORA module to VCC for stable performance, where the GND pins of both modules are connected to the closure of the circuit. The 3.3 V logic level of the LORA RA-02 module makes exact control of energy as significant. In essence, this means that it is fully compatible with ESP32. For data transmission, LORA's MOSI pencil (master out slave-in) is connected from the ESP32 to the GPIO23 so that the ESP32 can provide instructions and data to the form. PIN MISO (Master in Slave Out) is connected to GPIO19 and returns the data received by the LORA module to the EP32. The SCK PIN series is connected to the GPIO18 and synchronizes the ESP32 and LORA clock during SPI communication. The CS pin is also connected to the GPIO5, which uses the ESP32 to select or disable communication with the LORA module.

PROPOSED MODEL AND RESEARCH:

N	P	K	temperature	humidity	ph	rainfall	label
90	42	43	20.87974371	82.00274423	6.502985292	202.9355362	rice
85	58	41	21.77046169	80.31964408	7.038096361	226.6555374	rice
60	55	44	23.00445915	82.3207629	7.840207144	263.9642476	rice
74	35	40	26.49109635	80.15836264	6.980400905	242.8640342	rice
78	42	42	20.13017482	81.60487287	7.628472891	262.7173405	rice
69	37	42	23.05804872	83.37011772	7.073453503	251.0549998	rice
69	55	38	22.70883798	82.63941394	5.70080568	271.3248604	rice
94	53	40	20.27774362	82.89408619	5.718627178	241.9741949	rice
89	54	38	24.51588066	83.5352163	6.685346424	230.4462359	rice
68	58	38	23.22397386	83.03322691	6.336253525	221.2091958	rice
91	53	40	26.52723513	81.41753846	5.386167788	264.6148697	rice
90	46	42	23.97898217	81.45061596	7.50283396	250.0832336	rice
78	58	44	26.80079604	80.88684822	5.108681786	284.4364567	rice
93	56	36	24.01497622	82.05687182	6.98435366	185.2773389	rice
94	50	37	25.66585205	80.66385045	6.94801983	209.5869708	rice
60	48	39	24.28209415	80.30025587	7.042299069	231.0863347	rice
85	38	41	21.58711777	82.7883708	6.249050656	276.6552459	rice
91	35	39	23.79391957	80.41817957	6.970859754	206.2611855	rice
77	38	36	21.8652524	80.1923008	5.953933276	224.5550169	rice
88	35	40	23.57943626	83.58760316	5.85393208	291.2986618	rice
89	45	36	21.32504158	80.47476396	6.442475375	185.4974732	rice
76	40	43	25.15745531	83.11713476	5.070175667	231.3843163	rice
67	59	41	21.94766735	80.97384195	6.012632591	213.3560921	rice
83	41	43	21.0525355	82.67839517	6.254028451	233.1075816	rice
98	47	37	23.48381344	81.33265073	7.375482851	224.0581164	rice
66	53	41	25.0756354	80.52389148	7.778915154	257.0038865	rice
97	59	43	26.35927159	84.04403589	6.286500176	271.3586137	rice

Figure 4 Kaggle Dataset

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PROPOSED MODEL :

A bagging approach is used with machine learning model RF. The model is trained on a Kaggle dataset with NPK values, temperature, humidity, pH, and rainfall information. The accuracy level of these models is compared, and the most accurate model is selected for crop recommendation. The RF calculation gives the highest level of accuracy in classification.

RANDOM FOREST MODEL ACCURACY :

Model Accuracy: 99.32%

Classification Report:

	precision	recall	f1-score	support
apple	1.00	1.00	1.00	23
banana	1.00	1.00	1.00	21
blackgram	1.00	1.00	1.00	20
chickpea	1.00	1.00	1.00	26
coconut	1.00	1.00	1.00	27
coffee	1.00	1.00	1.00	17
cotton	1.00	1.00	1.00	17
grapes	1.00	1.00	1.00	14
jute	0.92	1.00	0.96	23
kidneybeans	1.00	1.00	1.00	20
lentil	0.92	1.00	0.96	11
maize	1.00	1.00	1.00	21
mango	1.00	1.00	1.00	19
mothbeans	1.00	0.96	0.98	24
mungbean	1.00	1.00	1.00	19
muskmelon	1.00	1.00	1.00	17
orange	1.00	1.00	1.00	14
papaya	1.00	1.00	1.00	23
pigeonpeas	1.00	1.00	1.00	23
pomegranate	1.00	1.00	1.00	23
rice	1.00	0.89	0.94	19
watermelon	1.00	1.00	1.00	19
accuracy			0.99	440
macro avg	0.99	0.99	0.99	440
weighted avg	0.99	0.99	0.99	440

Figure 5 Model Accuracy

CONFUSION MATRIX :

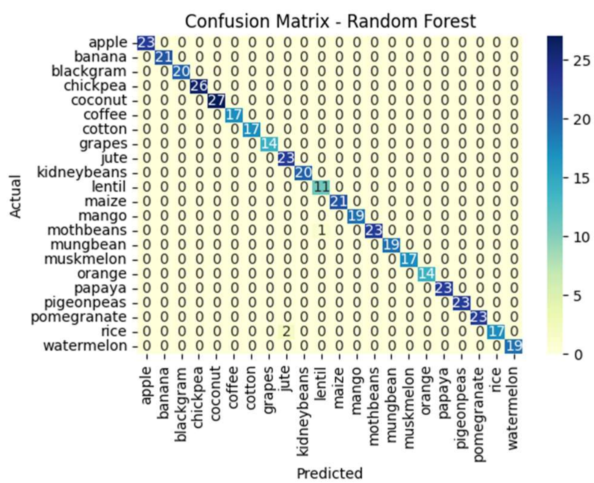

Figure 6 Confusion Matrix

PREDICATION RESULTS :

```
Enter values for prediction:
Enter Nitrogen : 91
Enter Phosphorous: 56
Enter Potassium: 37
Enter Temperature: 23.4
Enter Humidity: 80.5
Predicted Crop: rice
```

Figure 7 Prediction Results

RICE LEAF DISEASE DETECTION :

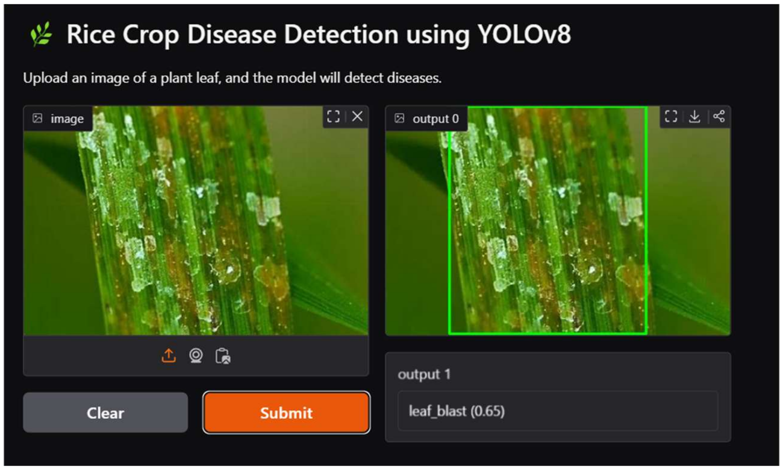

Figure 8 Rice leaf Disease Detection

CONCLUSION :

The Crop Suggestion System suggests crops depending upon soil nutrients, temperature, humidity, and the moisture level. Long-range transmission enables the data collection of IoT devices and Firebase storage as a cloud service. Up to 10 kilometers of distance is covered while broadcasting data under line-of-sight conditions. The system experimentally examines multiple machine learning approaches, and RF provides maximum accuracy of 99.32%.

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