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Smart Farming Application: Leveraging AI, Soil Analysis, and Weather Data for Optimized Crop Cultivation and Sustainable Agriculture

Sanskriti Sahu[1], Tejasva Ukey[2], Jagriti Singh[3], Ashutosh Yadav[4], Samiksha Shukla[5]
B.Tech Student, Department of Information Technology, Government Engineering College, Bilaspur(C.G.).

Abstract: ***Today, in agriculture: the modern farmer struggles with both high crop yield maximization and also simultaneously achieving sustainable farming practices. This paper describes an artificial intelligence (AI) based soil analysis application coupled with real-time weather data to assist in crop cultivation for developing smart farming. The app has increasingly been used for crop search, as well besides the convenience of providing information on crops giving helpful hints on sowing season and fertilizer needs to tread water footprint exercises by knowing base fertilizer use rates upfront till market prices! Based on the GPS data, it will analyze soil test reports: NPK values, pH levels of the area with weather conditions around your local and develop personalized farming roadmaps giving you a perfect step-by-step guide starting from preparing your land to harvesting. This pests and diseases identifier also has an option to upload images of the pest and helps you find the correct pesticide. Furthermore, it suggests the crops which can be grown according to user location and season along with advised healthy farming practices required for long-lasting soil fertility. In agriculture, this demonstration points to a probable future where technology can be used for data-driven guidance that enables farmers on actionable information — an end-to-end solution tailored around the essentials of sustainable crop production.***

Keywords: ***Modern agriculture, crop yield optimization, sustainable farming, smart farming app, AI, soil analysis, real-time weather data, crop cultivation, fertilizer needs, water footprint, NPK values, pH levels, GPS farming, pest identification, pesticide recommendations, location-based crop suggestions, healthy farming, soil fertility, data-driven agriculture, sustainable crop production.***

I. INTRODUCTION

Agriculture plays an necessary part in the food chain for the people of the world; still, the growers have generally been victims of climatic variability, deterioration of soil quality, and other fatal attack by pests and insects, which eventually diminishes the yield and profit. The husbandry system that had been successful in former decades is unfit to meet moment's agrarian demand. These problems have been given an occasion to be dived through recent technological advancements in areas of high applicability, similar as artificial intelligence, machine literacy, and data analytics, which present growers with data- driven perceptivity for informed decision- making both at crop civilization and resource operation situations. This paper presents a smart husbandry operation using AI, soil analysis, and GPS- grounded rainfall data to support growers in optimizing their crop product. operation personalizes all crop recommendations for the stoner, supported by the stoner's soil test reports and current rainfall conditions. It constructs substantiated roadmaps that guide growers through the entire growth cycle of their separate crops. In addition, the app has modules to identify pests using image recognition, deliver real- time request price updates, and suggest healthy husbandry practices. The integration of technology has so important to do with the effectiveness and sustainability of husbandry, empowering growers to make opinions in view of a fleetly changing agrarian terrain.

II. RELATED WORKS

The integration of technology in agriculture, known as precision agriculture, has garnered significant attention in recent years. Research has demonstrated that AI and machine learning can effectively analyze vast amounts of data to support decision-making processes in farming

1) *Precision Agriculture Systems:*

- *IBM Watson Decision Platform for Agriculture*: Utilizes AI and machine learning to analyze weather data, soil conditions, and satellite imagery for optimizing crop yields and resource management (IBM, 2019).

2) *Disease and Pest Management Apps:*

- *Plantix:* Employs image recognition technology to diagnose crop diseases and recommend treatments, demonstrating the potential of AI in pest and disease management (Plantix, 2020).
- *AgroStar*: Provides tailored fertilizer and pest control recommendations based on soil conditions and crop needs, focusing on specific aspects of crop management (AgroStar, 2021).

3) *Soil Health Management:*

- *Soil Sensors and Data Analytics*: Research on the use of soil sensors and data analytics to enhance soil fertility and optimize fertilizer use, contributing to more efficient and sustainable farming practices (Schröder et al., 2017).

4) *Integration of Technologies:*

- Many existing tools focus on individual aspects of farming rather than offering a comprehensive solution. This research aims to fill this gap by integrating crop recommendations, personalized roadmaps, pest management, and real-time weather and market data into a single application.

III. PROPOSED METHODOLOGY

A clear methodology is demanded so that growers can exploit the smart husbandry operation to its fullest by exercising all the features handed. The methodology then explains step by step on how to operate the app from its setup towards operation, both of crops and rainfall conditions amongst other effects. This will allow growers, through the operation, to handle husbandry matters with ease because it may give advice on crop civilization, soil operation, chemical pest control, and material request behaviours. The design of the operation is grounded on the explanation for icing the usability of the operation and making growers independent enough with the data for decision- making in enhancing their agrarian operations and adding productivity. Below is a detailed explanation of the way needed to use the smart husbandry operation.

1) *Getting Started:*

- *Download and Install*: Begin by downloading the smart farming app from your device's app store and installing it on your smartphone or tablet.
- *Create an Account*: Sign up for an account by providing basic information such as your name, location, and farming preferences.

2) *Input Crop Preferences:*

- *Search for Crops*: Use the app's search function to find information on the crops you are interested in growing. You can search by crop name, type, or growing season.
- *Review Crop Information*: Access detailed information about each crop, including the best growing seasons, required fertilizers, water footprint, nutrient benefits, and market prices.

3) *Submit Soil Report:*

- *Upload Soil Test Results*: If you have a soil test report, upload it to the app. This report should include data on soil parameters such as NPK levels and pH.
- *No Soil Report*: If you don't have a soil report, the app will still provide general recommendations based on typical soil conditions in your area.

4) *Receive Personalized Recommendations:*

- *View Roadmap*: Based on your soil report and local weather conditions, the app will generate a personalized roadmap that outlines the complete process from soil preparation to harvest.
- *Follow Steps*: The roadmap will guide you through each stage of crop cultivation, including planting, irrigation, fertilization, and pest management.

5) *Manage Pests and Diseases:*

- *Capture and Upload*: If you encounter pests or diseases, use the app to capture and upload photos.
- *Get Treatment Recommendations*: The app's image recognition system will identify the problem and suggest appropriate pesticides or treatments, along with application guidelines.

6) *Monitor Weather and Market Prices:*

- *Check Weather Updates*: Regularly check the app for real-time weather updates and forecasts, which will help you plan your farming activities and prepare for weather-related events.
- *View Market Prices*: Stay informed about current market prices for your crops to make better selling decisions and maximize your profits.

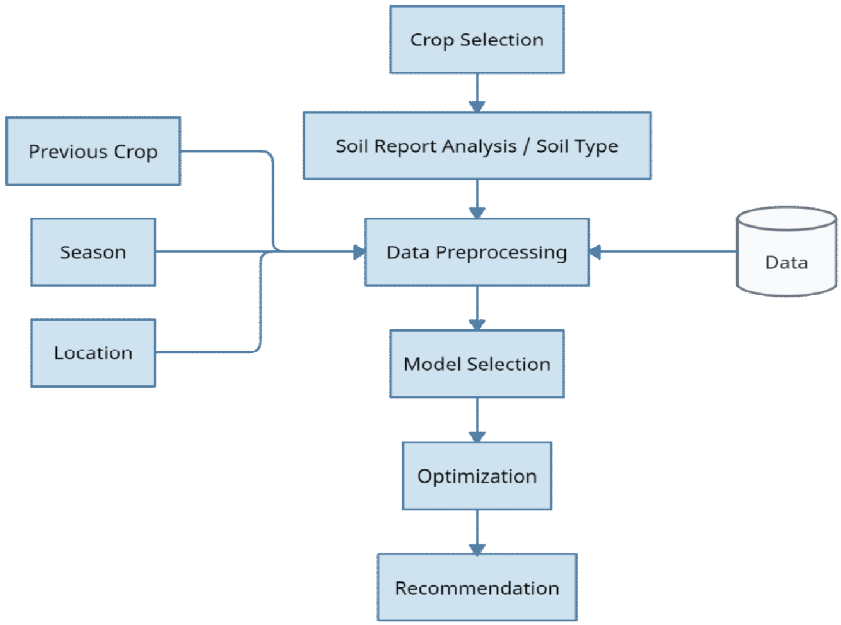
7) *Provide Feedback:*

- *Share Your Experience*: Use the app's feedback feature to share your experience and suggest improvements.
- *Receive Support*: Access customer support if you encounter any issues or have questions about using the app.

8) *Stay Informed:*

- *Regular Updates*: The app will provide regular updates with new features, farming practices, and data to keep you informed and improve your farming practices.

Data flow diagram: The data flow diagram below illustrates how information moves through the smart farming application, from user input to output generation:

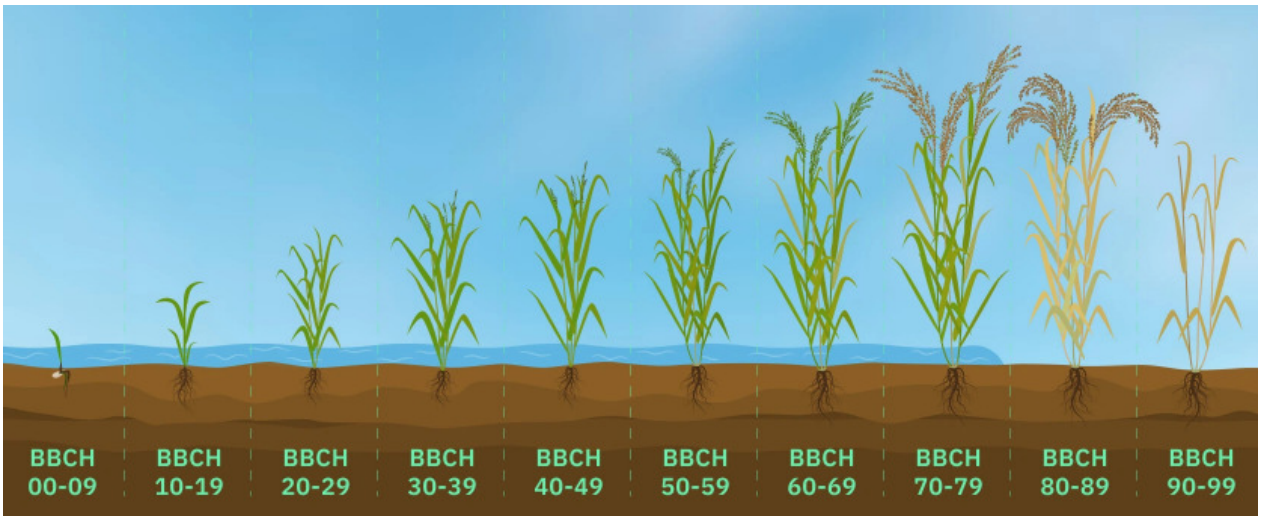


The following are datasets and analyses conducted by scientists in their research studies.

➢ *Water Footprint:*The water footprint measures the amount of water used to produce each of the goods and services we use. Water footprints of few of the crops are given below

Crop Type	Water Footprint (L/kg)	Description
Wheat	1,827	Average water required per kilogram of wheat produced.
Rice	2,500	High water usage due to paddy field cultivation.
Corn	900	Water footprint reflects irrigation needs in dry areas.
Soybean	2,000	Higher water use in regions with less rainfall.
Potatoes	500	Relatively low water requirement compared to cereals.
Tomatoes	560	Water footprint varies based on growing conditions.

Let us look at the stages of growth of rice through a diagram:-



BBCH:

- Biologische Bundesanstalt, Bundessortenamt and CHemical industry
- Used to identify the phenological development stages of plants.

➢ *Cropping Seasons:* Every crop has unique planting, harvesting, and processing procedures. However, each crop can be distinguished genetically based on the crop season. There are three main Cropping Seasons in India:

❖ Kharif
❖ Rabi
❖ Zaid

Lets have a look at this table that shows the time period and states where the specific crops are grown in a specific season:

SEASON	TIME PERIOD	CROPS	STATES
RABI	*Sown* October – December *Harvested* April - June	Wheat, Barley, Peas, Gram, Mustard.	Punjab, Haryana, Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Uttar Pradesh
KHARIF	*Sown* June – July *Harvested* September - October	Rice, Maize, Jowar, Urad, Cotton, Groundnut, Soybean	Assam, West Bengal, Coastal regions of Odisha, Andhra Pradesh, Telangana, Tamil Nadu, Kerala & Maharashtra
ZAID	*Sown* March – July *Harvested* Between Rabi and Kharif	Seasonal Fruits, Vegetables, Fodder crops	Most of the Northern and North-Western States

IV. RESULTS AND DISCUSSION

1) Problems of Traditional farming:Let us discuss the problems of traditional farming

2) Resource Management: The uneven distribution of water, fertilizer, and pesticide often causes widespread inefficiency in the management process, which could lead to overuse or underuse in traditional farming practices. This leads to higher costs, as well as increased environmental hazards, including water shortages and soil deterioration.

3) Pest and Disease Control: Traditional farming faces an impossible task in identifying and managing pests and diseases. Farmers are frequently forced to fall back on broad-spectrum treatments and may not be aware of problems until they have become widespread in the crop. But that can end up meaning more use of pesticides, and then failed crops.

4) Weather Uncertainty: Irrupting weather cycles are a huge problem with normal farming, and farmers are seldom in receipt of the timely updates on weather, so this contributes to their inability for active engagement and proper planning.

5) Market Pricing: A farm of a poor farmer always suffers in getting recent market prices for his various agricultural produce. The missing information may result in poor selling decisions and reduced profits.

Results:

This AI-driven application will show emerging results favouring crop yield optimization and advocating sustainable farming practices. It enables farmers to make informed decisions throughout different stages of crop production by providing customized recommendations that combine real-time weather data with soil analysis.

- Soil Analysis Accuracy: Incorporating soil analysis data (NPK values, pH levels) from soil test reports and GPS-based information provides more accurate and localized recommendations. Farmers using the app could choose the correct crops for their soils, resulting in improved soil management and nutrient efficiency. Farmers who followed AI-generated advice, reported higher yields over conventional methods.
- Fertilizer Optimization: Over-fertilization, a common issue in traditional farming, was mitigated by the app's ability to provide accurate fertilizer requirements based on soil test reports. By recommending the ideal rates and types of fertilizers, the app reduced fertilizer use, cutting down on environmental impacts by reducing nutrient leaching into water bodies. Farmers will also benefit financially from savings on fertilizer costs.
- Water Footprint Reduction: Crop-specific water requirements and the app's guidance on when and how much irrigation to apply will help conserve water. In regions affected by water scarcity, the app can suggest alternative crops that requires less water while maintaining profitability, translating to a significant reduction in water use, indicating significant water conservation potential.
- Pest and Disease Control: The pest identification function will havesignificant accuracy in identifying common pests and diseases from images uploaded by farmers. By offering suitable pesticide recommendations, farmers will be able to minimize crop losses. The app will promote environmentally friendly pest control practices, contributing to sustainable farming.
- Weather Integration for Crop Decisions: The integration of real-time weather data will enable farmers to adjust sowing dates, irrigation schedules, and pesticide applications based on current climate information. Consequently, farmers will have reduced weather-related risks, such as crop damage from extreme events, and timed inputs like fertilizers and pesticides for maximum effectiveness.
- Crop Selection and Market Insights: The app will help farmers diversify crop production based on location-specific crop suggestions, seasonal data, and market demand. Farmers will experience increased profits from better alignment with market demand and timing, avoiding oversupply of crops in the market.

V. CONCLUSION

The integration of machine literacy(ML) into agrarian practices through the smart husbandry operation represents a significant advancement in ultramodern husbandry. By employing the power of data analytics and AI, the operation will give growers with customized recommendations for crop civilization, resource operation, pest and complaint control, and request analysis. This exploration demonstrates that ML can effectively address numerous of the challenges associated with traditional husbandry, including hamstrung resource use, pest and complaint operation difficulties, rainfall unpredictability, and request pricing issues.

The results of the perpetration of smart husbandry have shown notable advancements in tilling effectiveness and productivity in former exploration studies too. growers have endured increased crop yields, reduced input costs, and enhanced decision- making capabilities. The app’s individualized roadmaps and real- time data integration will have major significance in optimizing agrarian practices and promoting sustainability.

Still, challenges similar as data integration, stoner relinquishment, and connectivity issues remain. Addressing these challenges is pivotal for maximizing the app’s impact and icing its wide relinquishment. Despite these hurdles, the positive issues of this exploration punctuate the transformative eventuality of ML in husbandry. By continuing to introduce and upgrade agrarian technologies, we can further enhance husbandry practices, support sustainable development, and contribute to the unborn adaptability of the agrarian sector.

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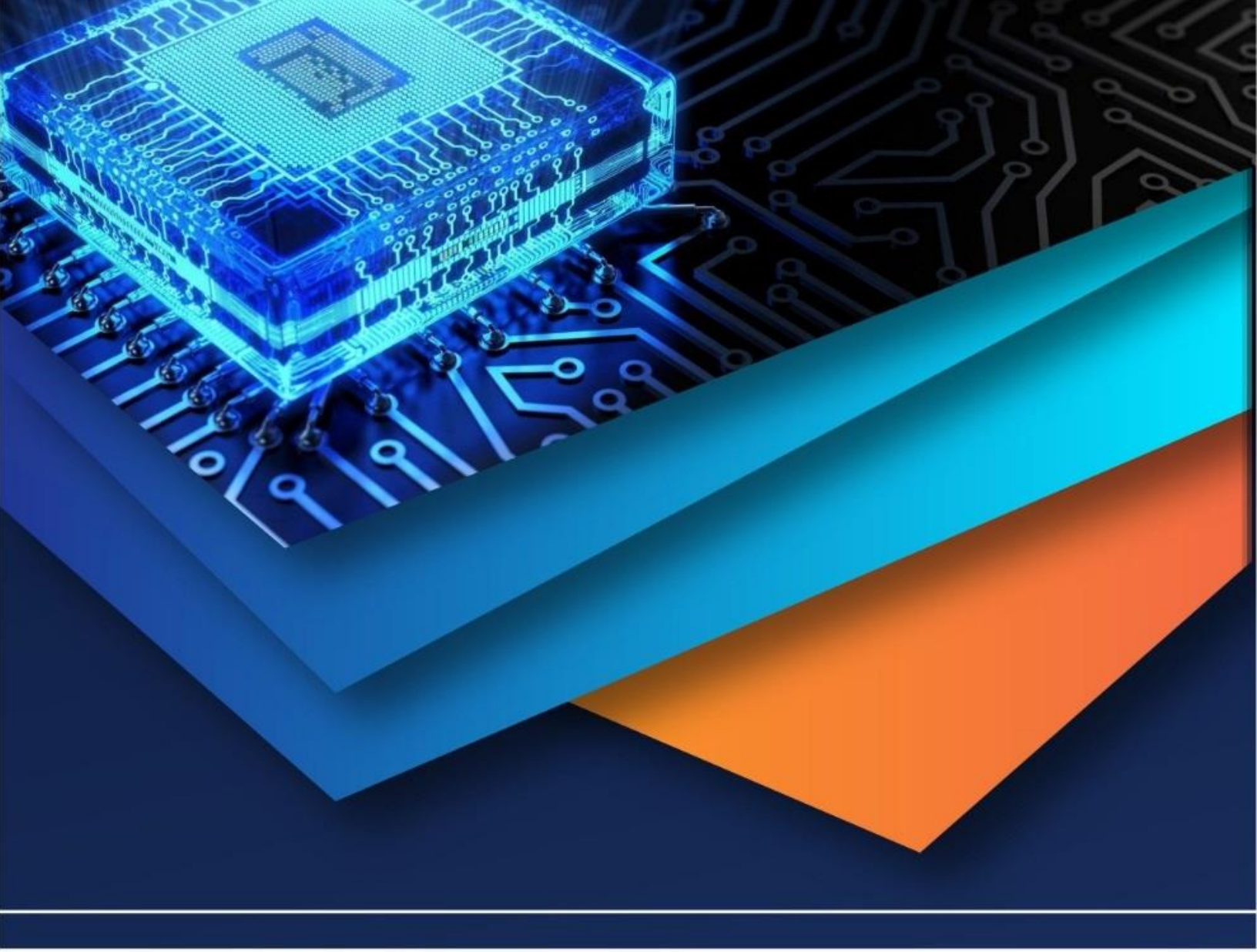

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