

A Review on Crop Prediction and Soil Nutrient Analysis

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Abstract— Agriculture plays a role in India's economy serving as the backbone of the country. Our main objective is to address the standing challenges faced by agriculture, which often involve inefficient traditional methods, increased expenses, and suboptimal yields. Therefore, it is crucial to make progress in this field. To tackle this issue, we are developing a solution that can significantly advance agriculture with accuracy. By incorporating sensors for NPK (Nitrogen, Phosphorus, Potassium) analysis, we enable real-time data collection on soil levels. This eliminates guesswork and approximations when applying fertilizers. The data is collected at the cloud and analyzed using Naive Bayes algorithm. Our project aims to provide farmers with crop predictions tailored to their specific soil conditions and regional climate. The method proposed here on analyzing the soil nutrients, soil temperature, humidity and rainfall using sensor nodes. By leveraging the potential of Machine Learning model such as Naive Bayes and Cloud computing, we aim to process data faster and make accurate predictions. The results of our research efforts have the potential to be transformative for farmers. They will gain the ability to make informed decisions leading to crop yields, reduced costs, and long-term sustainability.

Keywords— IOT, AI/ML, Smart Agriculture

I. INTRODUCTION

The advancement in technology and its application is essential for improvement in agriculture across the globe. Numerous studies have been conducted that have been

The existing systems [3] and [4] make use of various sensors to collect and transmit data via data transfer protocol. The information about the several environmental elements is provided by the collected data. The most efficient way to boost agricultural productivity is not solely to monitor climatic conditions. Countless other factors also contribute to a greater degree of productivity loss. These factors are discussed in [1], [2] and [6]. Therefore, automation needs to be used in agriculture to solve these issues. The main goal of the work is to develop a model of iterative which is capable of real-time monitoring and analysis. The ML models are trained on the data acquired from various Indian government portal which includes NPK values and environmental factors. The [3] and [11] use ML models make use of classification techniques and help farmers in predicting crops based on a set of threshold parameters. As maintaining the proportion of NPK in soil is essential for better crop yield, the model accurately predicts the required proportion based on the desired crop and advises farmers in taking appropriate decisions. An intuitive, userfriendly and easily accessible platform will be developed in [11] so that farmers can access and interpret AI-generated recommendations.



II. LITERATURE REVIEW

Alfred, Rayner and Obit, Joe Henry and Chin, Christie PeiYee and Haviluddin, Haviluddin and Lim, Yuto[[1]] This study examines the transformational influence of IoT, big data, and machine learning on Smart Agriculture, specifically in rice production. It describes a mapping framework for rice innovative farming, including modeling data and machine learning techniques used in both the initial and final stages. The main takeaway is the critical importance of efficiently merging BD, ML, and IoT to revolutionize conventional rice cultivation processes and usher in a new age of intelligent and precision agriculture.

A. Banerjee,[[2]]This proposed system utilizes two strategically positioned sensor nodes within the agricultural setting, enabling the collection and transfer of information to a central server. The effectiveness of the system in closely monitoring a diverse range of environmental factors empowers farmers to receive real-time updates, thereby augmenting their decision-making capabilities and overall productivity. Following meticulous evaluation, the model demonstrated outstanding performance within a specific range. In summary, this paper delves into the potential benefits and challenges of integrating Wireless Sensor Network (WSN) technology into intelligent farming systems. Furthermore, it sheds light on promising areas for further exploration in this domain.

Bashir, Rab Nawaz and Bajwa, Imran Sarwar and Shahid, Malik Muhammad Ali[[3]] This article examines the impact of soil salinity on agricultural productivity and proposes a solution for it using Internet of Things . To assess the agronomic consequences of the suggested approach, a cotton crop is cultivated in an area affected by salt. To predict future leaching needs, a Naive Bayes classifier is trained and evaluated using temperature and soil salinity data. Evaluation metrics including f-measures, accuracy, precision, and recall are used in measuring classifier's performance.

K. K. Ghanshala[[4]] This cutting-edge system uses solar energy sources, nodes for sensor data, a nitrogen

phosphorous potassium sensor, an Arduino computing element, and an internet-connected Zigbee module to manage watering while also analyzing soil nutrients, temperature, and air humidity. The Arduino serves as the core processing unit for crop growth, including a range of sensors such as temperature, humidity, wetness, soil pH, and the metos nitrogen phosphorous potassium sensor.

R. Gupta et al[[5]]The presented research introduces an innovative crop recommendation system that employs Map Reduce and K-means clustering, yielding efficient computational outcomes. The model extensively addresses various crops, evaluating their yield per area, while also taking into consideration the soil type and seed varieties corresponding to the specific cultivation practices in a given region.

G. Kaur[[6]]This paper compares different computer models to figure out soil nutrients in two districts in Maharashtra, India. They use data from the Indian government about soil health for training and testing the models. They noted that one model, Random Forest Regression, works better for Nitrogen , Phosphorus , and Potassium than the others.

They split the data into 80 percent for training the models and 20 percent for testing to make sure the models work well. The evaluation numbers for both sets of data show that the models fit the data well.

Khan, Arfat Ahmad and Faheem, Muhammad and Bashir, Rab Nawaz and Wechtaisong, Chitapong and Abbas, Muhammad Zahid[[7]] The focus of this study is the importance of precise, real-time fertilizer use for effective and lasting precision farming. The investigation presents a method for suggesting fertilizers, leveraging machinelearning. This method depends on instant soil fertility information, gained through an Internet of Things (IoT) assisted map. The research uses machine learning tools like GNB, KNN, SVM, and LR for apt fertilizer suggestions. After review, the GNB model proved most accurate. It delivered 96 percent and 94 percent correctness in training and testing stages, respectively.

N. V. S. Krishna, P. Neeraj, B. Surya, B. V. Prudhvi and V.

H. Deepthi[[8]] This proposed system helps upcoming farmers by guiding them through the process of planting the appropriate soil crops using machine learning algorithms. The system is educated using an algorithm based on random forest to make suggestions to farmers and assist them in harvesting successfully.

M. Masrie[[9]]The suggested system has an optical transducer, made by merging a light detection and light transmission system. We use the Arduino Uno micro-controller to run the light source in this transmission setup. Plus, it collects data from the light detection system. It also powers the liquid crystal display and manages functions to operate this display.

M. Pyingkodi, K. Thenmozhi, M. Karthikeyan [[10]] This device displays soil characteristics such as nitrogen, phosphate, and potassium in actual time. The tools used assist in determining soil quality in order to increase agricultural output. The article examines and analyzes various nutrient levels in soil. It makes use of granular estimation of density and a type of computer technology known as machine learning. Nutrients like as nitrogen, phosphorous, and potassium are measured using an NPK sensor coupled to an Arduino and soil sensor. The technology determines soil nutrient concentration utilizing these sensor components and a mass spectrogram.

S. P. Raja, B. Sawicka, Z. Stamenkovic and G. Mariammal[[11]] presents a machine learning strategy to predicting crop and crop yield utilizing the felon dataset and several feature selection approaches like MRFE, RFE, and Boruta. These characteristics are chosen and fed into classifiers such as kVM, SVM, NB, and DT algorithms to ensure correct classification and results.

V. Reddykapa et al[[12]] This paper introduces innovative methods for estimating Nitrogen, Phosphorous, and Potassium levels in soil in real time, eliminating the need for chemicals. One technique uses conductivity of electric current and pH sensors to collect data, and ML to determine the Nitrogen, Phosphorous, and Potassium values. Another approach uses optical sensors to measure light absorption and reflection, using regression techniques to estimate these

parameters. Both approaches categorize the N, P, and K values into multiple groups with an accuracy of more than 75%. Additionally, we have developed a handheld electronic device that utilizes these techniques to accurately measure N, P, and K levels. Overall, these methods have the potential to greatly optimize fertilizer usage, ultimately leading to greater efficiency and cost savings.

Saha, Pallabi and Kumar, Vikas and Kathuria, Samta and Gehlot, Anita and Pachouri,Vikrant and Duggal, Angel Swastik[[13]]In this enlightening discourse, readers will uncover valuable insights and notions for revolutionizing the utilization of technology in the realm of Precision Agriculture. By seamlessly integrating IoT and WSN technologies, agriculturists can seamlessly accumulate and evaluate real-time data regarding pivotal elements such as environmental circumstances, crop maturation and wellbeing, soil excellence, and nutrient levels. Due to the potency of predictive analytics, this data can subsequently be exploited to formulate well-informed judgments on irrigation, pest control, fertilizer usage, and the overall optimization of agricultural production. The discussion expertly examines the critical WSN attributes required for agricultural precision, including networks of sensors, precise irrigation, comprehensive tracking of crops, effective agricultural safeguarding, soil monitoring, predictive analytics, reduced labor costs, and increased efficiency.

F. K. Shaikh, S. Karim, S. Zeadally and J. Nebhen [[14]] presents a new way of Smart agriculture. In that they used various new technologies such as WSN, drones, IoT to observe the environment. In this paper the authors discuss the various ways for higher yield through better management and to implement better efficient practices. The author discusses the difference between traditional agriculture from smart agriculture. The different sensors used, identify the key role in smart agriculture.

Tomar, Vandana and Mandal, Vinay Prasad and Srivastava, Pragati and Patairiya, Shashikanta and Singh, Kartar and Ravisankar, Natesan and Subash, Natraj and Kumar,

Pavan[[15]]The scholars of this scholarly article employ Remote Sensing of Earthly Yield (REY) to investigate the effects of fertilizer treatments, evaluate crop yield, and modify application rates in a distinct geographic area situated within the Kuru region. A significant correlation is established between NDVI values and REY through the utilization of a sturdy linear regression model. The study proposes a wide array of cropping systems based on the triple-based method, as well as the implementation of satellite-mounted sensors to derive NDVI products, which enable comprehensive and pragmatic monitoring of agricultural productivity.

A. Gap Identification

Based on our extensive analysis of numerous methods, we identified the following areas that need focus.

1. Wide spread implementation of smart agricultural practices and automation.
2. Eradication of old agricultural practices and implementing new smart agricultural techniques.
3. More emphasis should be given on automating small tedious tasks/processes.
4. Improving the ML models to accurately predict the necessary crops to be grown.
5. Adding more accurate sensors to evaluate the environment and getting accurate values.
6. Integration of additional sensors to existing system for better crop yield.
7. Implementation of mobile app for effortless suggestion of crops to farmers with higher accuracy.
8. Making the system portable and seamless connection to users.
9. Making the system less expensive and less bulky.

B. Findings from Literature Survey Figure 1 shows

comparison of methodology used in

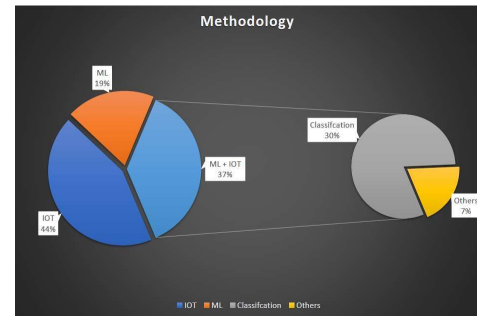


Figure 1 : Methodology Comparison the

research papers and articles.

- Around 19% of the research contributed to this area of study is purely based on leveraging ML algorithms for analyzing data.
- Around 44% of the research on understanding the need and importance of N, P and K values and their further analysis is done by using IoT and implementing hardware to study crop behaviour.
- And 37% of the research is focused on leveraging the potential of ML models for data analysis and predictive analysis, while integrating it with hardware of some sort.
- While ML models were used in analyzing crop data, the accuracy for these algorithms were quite low.
 - o In paper [7] Gaussian Naïve Bayes classifier was used which delivered only 96% accuracy.
 - o Paper [11] discusses the use of kVM, SVM, NB, DT classifiers for classification of crops

III. EXISITING METHODOLOGIES

[1] The author presents this methodology which highlights the major significance of collectively using BD, ML, and IoT technologies. The investigation presents an elaborate mapping framework delineating the actions involved in smart farming for rice. It delves into the utilization of data throughout the process and identifies ML algorithms deployed in both the phases of rice

cultivation and postproduction. The investigation emphasizes the pivotal nature of this integration in revolutionizing traditional rice farming techniques and ushering in next phase of intelligence in agriculture with precision for rice. [2] The system presented by the author showcases the implementation of a smart agricultural system that employs Wireless Sensor Network technology. The setup comprises of two nodes of sensors strategically placed across the farm that send data to a central base station. Its principal goal is to supervise varied environmental conditions and supply farmers with immediate information to help them make educated decisions and increase output. [3] The primary goal of this system is to tackle the effect of soil salinity on agriculture through the use of IoT technologies and machine learning predictive modeling. Further the author tells the challenges presented by soil salinity in agriculture, with a particular focus on its detrimental effects productivity and crop growth. The methodology presented involves the use of IoT system with a Naive Bayes classifier model. This classifier is trained and tested on existing data that includes information on soil salinity and temperature. The evaluation metrics collectively evaluate the model's capacity to predict the essential leaching prerequisites. [4] The author addresses the usage of solar panels equipped with sensor nodes such as temperature, humidity, wetness, soil pH, and metos NPK sensors. Arduino serves as the core processing unit for data collecting and analysis. The zigbee wireless module handles communication between the CPU (central processing unit) and the sensor nodes. The data acquired by sensor nodes from the soil and surroundings is analyzed using algorithms and procedures. This enables intelligent irrigation and data-driven decisionmaking, which improves crop growth and agricultural output. [5] The work presented in this study introduces a novel system that provides recommendations regarding the optimal choice of crops to cultivate in diverse geographical regions. This system efficiently employs two distinct methodologies, namely MapReduce and K-means clustering, to streamline the decision-making process. The system analyzes numerous crop species and their corresponding yields within specific geographic areas. [6]

This research presents an in-depth comparison of ML models spanning two areas of

Maharashtra, an Indian state, for estimating soil nutrients using optical remote sensing and other additional data. Indian government. This work uses soil health data to train and evaluate algorithms. The results revealed that RFR outperformed other models for nitrogen (N), phosphorus (P), and potassium (K). To maintain model stability, data from the training dataset was split into 80 percent training and 20 percent testing. Evaluation numbers are used to train and test data sets that demonstrate a strong match. [7] The methodology used in this research focuses on devising an accurate real-time fertilizer recommendation system for precision agriculture. The research aims to develop a fertilizer recommendation method that relies on machine learning techniques to utilize real-time fertility data obtained through the Internet of Things mapping. Real-time fertility data is gathered using IoT-enabled mapping, likely involving sensors or devices placed in the field to monitor soil characteristics such as nutrient levels, pH, moisture, etc. To generate context-aware fertilizer recommendations, various machine learning models are employed, including GNB, KNN, SVM, LR. The effectiveness of each model is assessed using evaluation metrics, likely including accuracy, precision, recall, and possibly others. According to the evaluation, the Gaussian Naive Bayes model stands out as the most accurate, scoring 96% on the data used for training dataset and 94% on the data set being tested. [8] The author uses a comparative analysis of 3 algorithms namely KNN, DTR and SVR. The comparison was done on the basis of RMSE and MSE. Through this comparison the author came to the conclusion that KNN and DTR has the highest RMSE measuring 2.22 and 2.50 and Support vector regression had 0.5. Similarly, MSE for SVR is 0.3, for KNN and DTR is 4.90 & 6.29. [9] In this the author uses optical transducer unit by integrating both a LTS and a LDS. The voltage reading obtained has been compared to a threshold value to classify the nutrient shortage in soil into three categories: high, medium, and low. This approach measures each nutrient's absorption rate. [10] The suggested system employs a number of software and hardware elements to illustrate soil properties such as nitrogen, phosphorus, and potassium in



real time. This system consists of many hardware sensors that detect soil quality and offer information about soil quality for improved crop output. The article analyzed and compared different soil nutrient levels using grain density estimation and a machine learning algorithm. The raw data such as nitrogen, phosphorus, potassium is measured through NPK sensor connected with arduino and soil sensor. In this system the soil nutrient content is determined through sensor element and mass spectrogram. [11] Provides ML model strategy for predicting crop and crop production utilizing the Felin dataset and several feature choosing approaches such as MRFE, RFE, and Boruta. These features are selected and processed into the classifiers which includes kVM, SVM, NB, DT algorithms for accurate classification and outcome. [12] The author describes two approaches for estimating nitrogen, phosphorus, and potassium that yield real-time findings without the use of chemicals. The first approach employs conductivity of electricity and pH meters to assess these factors in the soil, and ML algorithms to calculate the nitrogen, phosphorous, and Potassium levels. The second kind of approach utilizes optical technology to detect the quantity of light that is reflected and absorbed by the soil, then use methods of regression to estimate the amounts of nitrogen, phosphorus, and potassium. In all situations, the value of nitrogen, phosphorus, and potassium are assigned to separate classes. We get more than seventy-five percent correctness in both scenarios. The procedures described above are used to create an electric gadget (handheld) that measures the values of the three parameters. The proposed strategies can improve fertilizer consumption while also assisting farmers in producing crops that are both inexpensive and efficient.

[13] This technique provides ways to improve the use of technology in Targeted Agriculture. Data is gathered in actual time on the surrounding environment, development of crops and well-being, soil health, and the amount of nutrients using IoT and WSN technologies. Predictive analytics are utilized to evaluate the collected data, enabling for informed decisions on water supply, controlling pests, fertilizer's usage, and output from

agriculture optimization. The report discusses key WSN aspects in precise farming, including networks of sensors, accurate irrigation, tracking of crops, safeguarding crops, soil monitoring, and predictive analytics.

[14] The methodology described in the paper focuses on introducing a new approach to Smart Agriculture that incorporates several advanced technologies like WSN, the IoT, and drones. The information is collected through numerous sensors placed in the soil and environment. Drones are utilized to observe and monitor the agricultural environment, providing valuable data and insights. [15] The authors used REY to explore fertilizer treatments, crop yield assessments, and application rate modifications unique to a specific location in the Kuru region. A substantial link is found between NDVI values and REY using a robust linear regression. The study proposes a variety of triple-based cropping techniques and NDVI solutions produced from satellite-mounted sensors for comprehensive and harvest tracking.

IV. DATASET

Rishi Gupta et al. [5] Seven Datasets were used in this article. The `crop_production.csv` file comprises comprehensive information pertaining to all the states and their respective districts. This dataset contains information on one hundred fifty crops, including volumes of production and cultivation areas, from 2000 to 2014. The datasets provide useful information on the daily average temperature values recorded in numerous cities in India between 1995 and 2020. Finally, the Rainfall in India data provides a credible source of information on the mean monthly precipitation levels observed in various regions across the country between 1901 and 2015.

S. P. Raja et al. [11] Felin Dataset is used here for evaluating and training various ML classifiers. Felin's dataset includes both the yield of potato tubers and the production of dry matter and starch. These data are the average over seven years, and their accompanying coefficients of variation, presented as percentages.

V. PERFORMANCE EVALUATION METRICES

Rab Nawaz Bashir, Imran Sarwar Bajwa, and Malik Muhammad Ali Shahid [3] Performance metrics such as



measures, accuracy, precision, and recall are used in measuring classifier's performance. The authors were able to achieve an accuracy of 85% using a Naïve Bayes Classifier, a f1-score of 0.897, precision of 1.000 and a recall of 0.812. Gunkirat Kaur, Kamal Das, and Jagabondhu Hazra [6] The authors used four linear and nonlinear regression models of which RFR performed best among them. NV Suresh Krishna et al [8] The authors were able to achieve an accuracy of 91.2% employing a RFC. S. P. Raja et al. [11] Authors use 5 different classifiers and evaluate them on their performance using performance metrics such as accuracy, kappa, precision, recall, specificity, f1-score, AUC, MAE and log loss. Random Forest performed exceptionally on Felin Dataset and had an accuracy of 87.43, Kappa 85.16, precision of 90.34, specificity of 95.67, f1-score of 89.72, AUC 92.39, MAE 0.3 and Log Loss of 0.04.

VI. CONCLUSION

This study reviews the different classification and regression approaches used to forecast crops in a certain location. It also reviews implementation of various hardware systems used for analyzing crop nutrients in different regions. The datasets used in these reports were either region specific or had less classes and hence resulted in lower performance. The major goal of this work is to examine and compare different algorithms as well as hardware implementations presented in 15 research papers. Based on review of various research papers focusing on crop prediction and soil nutrient analysis it can be concluded that around 19% of the research is focused on pure analysis using ML models, 37% of the research was implemented using both IoT and ML models and 44% of the research was implemented purely using IoT.

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