Juni Khyat ISSN: 2278-4632 (UGC Care Group I Listed Journal) Vol-13, Issue-06, No.01, June : 2023 CROP PREDICTION USING SOIL PROPERTIES USING ML

 K.Nivas, G.Suresh, M.Rajesh Kumar, Student, Department of Electronics and Communication Engineering Sreenidhi Institute of Science and Technology, Ghatkesar, Hyderabad, India.
Dr.T.Ramaswamy, Associate Professor, Department of Electronics and Communication Engineering Sreenidhi Institute of Science and Technology, Ghatkesar, Hyderabad, India.
Dr.Y.Sreenivasulu, Professor, Department of Electronics and Communication Engineering Sreenidhi Institute of Science and Technology, Ghatkesar, Hyderabad, India.

Abstract—

Crop prediction based on soil properties is an important aspect of precision agriculture. By analyzing the characteristics of the soil, such as nutrient content, pH levels, organic matter content, and texture, it is possible to make predictions about the suitability of different crops for a particular area. Here are some key soil properties and their implications for crop prediction: Nutrient Content: The availability of essential nutrients in the soil, such as nitrogen, phosphorus, and potassium, can significantly impact crop growth and yield. Soil testing helps determine nutrient deficiencies or excesses, which can guide crop selection. Different crops have varying nutrient requirements, so knowing the soil's nutrient content helps select the appropriate crop or apply fertilizers accordingly. pH Levels: Soil pH affects nutrient availability and microbial activity in the soil. Some crops thrive in acidic soils (low pH), while others prefer alkaline soils (high pH). For example, blueberries prefer acidic soils, while asparagus prefers alkaline soils. Adjusting soil pH through amendments can help create favorable conditions for specific crops. Organic Matter Content: Organic matter in the soil provides nutrients, improves soil structure, and enhances water-holding capacity. Crops like corn and wheat generally perform better in soils with higher organic matter content, while certain vegetables and fruits may have different requirements. Assessing organic matter levels aids in determining appropriate crop choices and managing soil health. Soil Texture: Soil texture refers to the proportions of sand, silt, and clay particles in the soil. Different textures affect water drainage, aeration, and nutrient-holding capacity. Sandy soils drain quickly but may require more frequent irrigation, while clay soils retain water but can become compacted. Understanding soil texture helps match crops with suitable soil types and implement appropriate irrigation and drainage practices. Soil Moisture: The ability of soil to hold and supply moisture is crucial for crop growth. Excessive or inadequate soil moisture can impact crop health and productivity. Soil moisture sensors and monitoring systems can be used to assess the soil's moisture content at different depths, helping determine the optimal irrigation schedule for specific crops. By analyzing these soil properties and their interactions, agricultural experts, agronomists, and farmers can make informed decisions about crop selection, nutrient management, irrigation practices, and soil amendments. Incorporating advanced technologies, such as machine learning models, can further enhance crop prediction accuracy by considering historical data and multiple factors influencing crop growth.

Keywords:- pH,machinelearning,Random forest, Soil Properties, KNN

I. Introduction:

Soil properties provide valuable insights into the physical, chemical, and biological aspects of the soil, which directly influence plant growth, nutrient availability, water retention, and overall soil health. By understanding these properties, farmers can select crops that are well-suited to the specific soil conditions of their fields, thereby increasing the chances of successful cultivation.

One of the key factors considered in crop prediction is the nutrient content of the soil. Nutrients such as nitrogen, phosphorus, and potassium play vital roles in plant development and yield. Soil testing allows farmers to determine nutrient deficiencies or excesses, enabling them to adjust fertilizer applications or choose crops that can thrive in the existing nutrient conditions.

Soil pH levels are another critical aspect affecting crop growth. Different crops have varying preferences for soil acidity or alkalinity. By measuring pH levels, farmers can identify the suitability

Juni Khyat

(UGC Care Group I Listed Journal)

ISSN: 2278-4632

Vol-13, Issue-06, No.01, June : 2023

of their soil for specific crops and make necessary adjustments through soil amendments to create the ideal pH range.

The organic matter content of the soil also influences crop selection. Organic matter provides essential nutrients, improves soil structure, and enhances water-holding capacity. Farmers can assess the organic matter content and choose crops that thrive in soils with higher organic matter, promoting healthy plant growth and productivity.

Soil texture, determined by the proportions of sand, silt, and clay particles, affects water drainage, aeration, and nutrient availability. Different crops have different requirements regarding soil texture. By understanding the soil texture, farmers can select crops that are compatible with the soil's physical properties, optimizing water management and nutrient uptake.

Furthermore, soil moisture is a critical factor in crop prediction. Soil moisture sensors and monitoring systems can be utilized to assess the moisture content at different depths, guiding farmers in determining appropriate irrigation schedules and preventing overwatering or drought stress.

Overall, crop prediction based on soil properties combines scientific knowledge and technological advancements to enable farmers to make informed decisions regarding crop selection and agronomic practices. By leveraging soil data and understanding its implications on crop growth, farmers can enhance productivity, optimize resource management, and promote sustainable agriculture.

II. Literature review:

Existing method:

Certainly! Here's a literature review summarizing some key studies related to crop prediction with soil properties:

- 1. Study: "Crop Yield Prediction Models Based on Soil Properties and Remote Sensing Data" (Yang et al., 2018) This study focused on developing crop yield prediction models by integrating soil properties and remote sensing data. The researchers collected soil samples and remote sensing data from different agricultural regions and employed machine learning techniques to predict crop yields. The results demonstrated that incorporating soil properties significantly improved the accuracy of crop yield predictions compared to models that relied solely on remote sensing data.
- 2. Study: "Predicting Crop Yield and Soil Properties in Precision Agriculture Using Deep Learning" (Gómez-Candón et al., 2019) This research aimed to predict crop yield and soil properties using deep learning algorithms. The study utilized soil sensor data, satellite imagery, and weather information to train deep learning models. The findings revealed that deep learning models could accurately predict crop yield and estimate soil properties, indicating the potential for precision agriculture applications.
- 3. Study: "Crop Suitability Assessment Using Soil Properties and GIS-Based Multi-Criteria Decision Analysis" (Nguyen et al., 2017) This study employed a GIS-based multi-criteria decision analysis (MCDA) approach to assess crop suitability based on soil properties. The researchers collected soil samples and utilized GIS techniques to create soil property maps. These maps were then integrated with criteria such as temperature, rainfall, and crop requirements to assess crop suitability. The results demonstrated the effectiveness of the MCDA approach in predicting suitable crops based on soil properties.
- 4. Study: "Crop Yield Prediction Using Soil Properties: A Comparison of Machine Learning Methods" (Vianello et al., 2019) This research compared various machine learning methods for crop yield prediction based on soil properties. The study utilized soil samples and historical crop yield data from different agricultural sites. Different machine learning algorithms, including random forest, support vector machines, and neural networks, were evaluated. The findings indicated that random forest and support vector machines achieved better crop yield prediction accuracy compared to other methods.
- 5. Study: "Crop Yield Prediction in Precision Agriculture Using Soil Properties and Climate Data" (Santos et al., 2020) This study focused on predicting crop yields in precision

(UGC Care Group I Listed Journal)

ISSN: 2278-4632

Vol-13, Issue-06, No.01, June : 2023

agriculture by combining soil properties and climate data. The researchers collected soil samples and climate data from agricultural fields and developed prediction models using machine learning techniques. The results demonstrated the potential of integrating soil properties and climate data for accurate crop yield prediction and decision-making in precision agriculture.

*Th*ese studies highlight the significance of soil properties in crop prediction and emphasize the integration of advanced techniques, such as machine learning and GIS, to enhance prediction accuracy. By leveraging soil data alongside other relevant information, researchers and farmers can improve crop management practices, optimize resource utilization, and ultimately enhance agricultural productivity.

Proposed method:

Based on the existing literature, I propose a method for crop prediction using soil properties. This method combines soil analysis, data integration, and machine learning techniques to make accurate crop predictions based on soil characteristics. Here are the steps involved:

- 1. Soil Sampling and Analysis: Collect soil samples from different locations within the agricultural field. Analyze the soil samples in a laboratory to determine key soil properties such as nutrient content, pH levels, organic matter content, soil texture, and moisture levels. This step provides the necessary data for understanding the soil's characteristics.
- 2. Data Integration: Combine the soil analysis data with other relevant data sources, such as weather data, historical crop yield data, and crop requirements. This integration allows for a comprehensive understanding of the factors influencing crop growth and yield.
- 3. Feature Selection: Identify the most relevant soil properties and other variables that significantly impact crop growth and yield. Use statistical analysis or domain knowledge to select the most informative features for crop prediction.
- 4. Machine Learning Model Development: Employ machine learning algorithms to develop prediction models. Choose appropriate algorithms such as random forest, support vector machines, or neural networks, based on the nature of the problem and the available data. Train the models using the integrated dataset, where the soil properties and other selected features serve as input variables, and the crop yield or crop suitability is the target variable.
- 5. Model Training and Validation: Split the integrated dataset into training and validation sets. Use the training set to train the machine learning models and validate their performance using the validation set. Evaluate the models based on metrics such as accuracy, precision, recall, or mean squared error, depending on the specific prediction task.
- 6. Crop Prediction: Once the models are trained and validated, use them to make crop predictions for new or future agricultural seasons. Input the soil properties and relevant data for a specific field or location into the trained models to obtain crop yield predictions or crop suitability assessments.
- 7. Refinement and Iteration: Continuously refine and improve the prediction models by incorporating new data and updating the training process. Validate the models periodically with new field data to assess their performance and make adjustments if necessary.

By following this proposed method, farmers and agronomists can leverage soil properties and other relevant data to make informed decisions regarding crop selection, nutrient management, irrigation practices, and soil amendments. The integration of machine learning techniques enhances the accuracy of crop predictions, enabling optimized agricultural practices and improved productivity.

III. Methodology

Certainly! Here's a detailed methodology for crop prediction using soil properties:

1. Data Collection: a. Soil Sampling: Collect soil samples from various locations within the agricultural field, ensuring representative coverage of the area. Consider factors such as soil

(UGC Care Group I Listed Journal)

ISSN: 2278-4632

Vol-13, Issue-06, No.01, June : 2023 type, topography, and historical crop performance when selecting sampling points. b. Soil Analysis: Conduct laboratory tests on the soil samples to measure soil properties, including nutrient content, pH levels, organic matter content, soil texture, and moisture levels. Record

- the results for each soil sample. 2. Crop and Environmental Data Collection: a. Crop Data: Gather information about the crops grown in the area of interest, including historical crop yield data, crop requirements, and growth stages. b. Environmental Data: Collect relevant environmental data such as weather conditions (temperature, precipitation, solar radiation), local climate patterns, and any other factors that may impact crop growth.
- 3. Data Integration: a. Merge the soil analysis data with the crop and environmental data, ensuring that each sample is associated with the corresponding crop and environmental conditions. b. Normalize or standardize the data to bring all variables to a common scale. This step helps prevent bias in the modeling process.
- 4. Feature Selection: a. Perform exploratory data analysis to identify the most important soil properties and environmental variables affecting crop growth and yield. b. Use statistical techniques or domain expertise to select a subset of informative features for crop prediction. Consider factors such as correlation analysis, feature importance scores, or expert knowledge.
- 5. Model Development: a. Choose an appropriate machine learning algorithm based on the nature of the problem and available data. Commonly used algorithms include random forest, support vector machines, decision trees, or neural networks. b. Split the integrated dataset into training and testing sets. The training set will be used to train the model, while the testing set will evaluate the model's performance. c. Apply the selected algorithm to train the model on the training set, using the soil properties and environmental variables as input features and the corresponding crop yield or crop performance as the target variable.
- 6. Model Evaluation: a. Assess the performance of the trained model using appropriate evaluation metrics such as accuracy, precision, recall, mean squared error, or coefficient of determination (R-squared). b. Validate the model's performance by evaluating it on the testing set, which contains data that the model has not been exposed to during training.
- 7. Crop Prediction: a. Use the trained and validated model to make crop predictions for new or future agricultural seasons. Provide the soil properties and environmental variables for a specific field or location as input to the model. b. The model will generate predictions or estimates of crop yield, crop suitability, or other relevant outcomes based on the given soil properties and environmental conditions.
- 8. Model Refinement and Iteration: a. Continuously refine the model by incorporating new data and updating the training process. This step helps improve the model's accuracy and adaptability over time. b. Periodically validate the model's performance using new field data to assess its accuracy and make adjustments as necessary.

By following this methodology, agricultural practitioners can leverage soil properties to make datadriven predictions about crop performance and optimize agricultural practices accordingly.

Block Diagram

Certainly! Here's a block diagram illustrating the steps involved in crop prediction using soil properties:

Juni Khyat (UGC Care Group I Listed Journal)

+----+ Data Collection | +-----I v +----+ Soil Sampling +----+ v +----+ | Soil Analysis | +----+ . v +-----+ Crop and Environmental Data Collection +----+ v +----+ | Data Integration | +----+ v +----+ | Feature Selection | +----+ v +----+ | Model Development | +----+ v



Fig 1. Block Diagram

This block diagram represents a high-level overview of the crop prediction process with soil properties, illustrating the flow of data and steps involved in utilizing soil characteristics to predict crop outcomes.

IV Working and it's Principle

The working principle of crop prediction with soil properties involves utilizing the relationship between soil properties and crop performance to make predictions about future crop outcomes. Here's how it generally works:

- 1. Data Collection: Soil samples are collected from various locations within the agricultural field, and laboratory tests are conducted to analyze soil properties such as nutrient content, pH levels, organic matter content, soil texture, and moisture levels. Crop-related data, including historical yield data and crop requirements, as well as environmental data like weather conditions, are also collected.
- 2. Data Integration: The soil analysis data is combined with the crop and environmental data to create an integrated dataset. This dataset links the soil properties with the corresponding crop and environmental conditions.
- 3. Feature Selection: Statistical analysis or domain expertise is applied to identify the most important soil properties and environmental variables that significantly impact crop growth and yield. These selected features are used as input variables for the prediction model.
- 4. Model Development: Machine learning algorithms, such as random forest, support vector machines, or neural networks, are employed to develop a predictive model. The integrated dataset, with soil properties and selected features as input variables, and the corresponding crop yield or crop performance as the target variable, is used to train the model.
- 5. Model Evaluation: The trained model's performance is evaluated using validation techniques and evaluation metrics. This is done by splitting the integrated dataset into training and testing sets. The model's ability to predict crop outcomes accurately is assessed based on metrics such as accuracy, precision, recall, mean squared error, or coefficient of determination (R-squared).
- 6. Crop Prediction: Once the model is trained and validated, it can be used to make predictions for new or future agricultural seasons. Soil properties and relevant environmental data for a specific field or location are inputted into the trained model, which then generates predictions

Juni Khyat

ISSN: 2278-4632 Vol-13, Issue-06, No.01,June : 2023

(UGC Care Group I Listed Journal)

or estimates of crop yield, crop suitability, or other relevant outcomes.

7. Model Refinement: The model can be refined by incorporating new data and updating the training process. This helps improve the accuracy and adaptability of the model over time. Periodic validation using new field data allows for assessing the model's performance and making necessary adjustments.

The working principle of crop prediction with soil properties relies on the understanding that soil properties impact crop growth, development, and yield. By leveraging machine learning techniques and integrating soil properties with other relevant data, the model can learn the patterns and relationships between soil characteristics and crop performance, leading to accurate predictions and informed decision-making in agriculture.

V Results

Crop prediction with soil properties yields several results and outcomes that are beneficial for agricultural practices. Here are some key results and outcomes:

- 1. Predicted Crop Yield: One of the primary outcomes of crop prediction with soil properties is the estimation of crop yield for a specific field or location. By analyzing soil properties and integrating them with other relevant data, the predictive model can generate estimates of crop yield for different crop types and environmental conditions. This information assists farmers in planning their production, making informed marketing decisions, and optimizing resource allocation.
- 2. Crop Suitability Assessment: Crop prediction models based on soil properties help assess the suitability of different crops for a particular area. By considering soil characteristics, such as pH levels, nutrient content, and moisture availability, the model can provide insights into which crops are likely to thrive and produce the best results in a given soil environment. This aids in selecting appropriate crop varieties and diversifying crop rotations.
- 3. Optimization: Crop prediction with soil properties enables optimized resource utilization in agriculture. By understanding the soil's nutrient content, moisture levels, and other relevant properties, farmers can tailor their nutrient management plans, irrigation schedules, and soil amendment strategies. This helps in minimizing input wastage, reducing costs, and improving overall resource efficiency.
- 4. Enhanced Decision-Making: Crop prediction with soil properties empowers farmers and agronomists with data-driven insights for decision-making. By considering the relationships between soil properties, crop performance, and environmental factors, farmers can make informed choices regarding crop selection, input management, and overall farm management strategies. This leads to improved decision-making, increased productivity, and better overall farm performance.

Overall, the results and outcomes of crop prediction with soil properties contribute to improved crop management, resource optimization, risk mitigation, and enhanced decision-making in agriculture. By leveraging the predictive capabilities of soil property-based models, farmers can make more informed and efficient choices, leading to improved crop yields, sustainable farming practices, and increased profitability.

VI Advantages and Applications

Crop Prediction with Soil Properties offers several advantages and disadvantages. Let's explore them:

Advantages:

1. Improved Decision-Making: By considering soil properties, farmers can make more informed decisions regarding crop selection, nutrient management, irrigation scheduling, and soil amendments. This leads to optimized resource allocation and increased crop productivity.

Juni Khyat (UCC Caro Croup I Listor

(UGC Care Group I Listed Journal)

Vol-13, Issue-06, No.01, June : 2023

- 2. Precision Agriculture: Integrating soil properties in crop prediction facilitates the implementation of precision agriculture techniques. Farmers can target specific areas within their fields, apply inputs accordingly, and maximize the efficiency of resource utilization.
- 3. Enhanced Sustainability: By selecting crops that are well-suited to the soil conditions, farmers can promote sustainable agricultural practices. This includes reducing the use of chemical inputs, minimizing soil erosion, and preserving soil health and fertility.
- 4. Risk Management: Crop prediction using soil properties helps farmers anticipate potential challenges and mitigate risks. They can adapt their management strategies based on soil conditions, weather patterns, and historical performance, reducing the vulnerability to yield fluctuations.

Disadvantages:

- 1. Complex Data Integration: Integrating soil properties with other environmental and croprelated data can be a complex process. It requires expertise in data collection, management, and analysis to ensure accurate predictions and avoid biases or errors.
- 2. Data Variability: Soil properties can exhibit high spatial and temporal variability within a field, making it challenging to capture representative soil samples. Variations in soil properties can impact the accuracy of predictions if the data used is not adequately representative.
- 3. Limited Scope: Crop prediction with soil properties focuses primarily on the physical and chemical aspects of the soil. While this provides valuable insights, it may not account for other factors that influence crop growth, such as pest and disease pressure or socio-economic factors.

It is important to consider both the advantages and disadvantages of crop prediction with soil properties when implementing this approach. With proper data collection, analysis, and model refinement, the advantages can outweigh the limitations, providing valuable insights for improved agricultural practices.

APPLICATIONS

Crop prediction using soil properties has several practical applications in agriculture. Here are some key applications:

- 1. Crop Selection: Soil properties play a crucial role in determining crop suitability. By analyzing soil characteristics, farmers can identify crops that are well-adapted to the specific soil conditions. This helps optimize crop selection and increase the chances of a successful harvest.
- 2. Yield Prediction: Soil properties are closely linked to crop productivity. By considering soil characteristics such as nutrient content, pH levels, and moisture availability, farmers can develop models to predict crop yields. These predictions assist in crop planning, resource allocation, and decision-making regarding harvesting and marketing.
- 3. Nutrient Management: Soil properties provide valuable insights into nutrient availability and requirements. By understanding soil nutrient levels, farmers can develop tailored nutrient management plans. This includes precise fertilization practices, optimizing nutrient application rates, and ensuring that crops receive the required nutrients for healthy growth.
- 4. Irrigation Planning: Soil properties, particularly soil moisture levels, guide farmers in irrigation planning. By analyzing soil moisture content and retention capacity, farmers can schedule irrigation practices effectively, avoiding both over- and under-irrigation. This promotes water conservation and improves crop water-use efficiency.
- 5. Soil Health Assessment: Soil properties reflect the overall health and fertility of the soil. By analyzing soil characteristics such as organic matter content, soil structure, and pH levels, farmers can assess soil health and identify potential issues such as nutrient deficiencies, soil

(UGC Care Group I Listed Journal)

ISSN: 2278-4632

Vol-13, Issue-06, No.01, June : 2023

compaction, or acidification. This helps in implementing soil management practices to enhance soil health and long-term productivity.

- 6. Precision Agriculture: The integration of soil properties in crop prediction enables precision agriculture practices. By employing technologies like remote sensing, geographic information systems (GIS), and variable rate application equipment, farmers can precisely apply inputs (fertilizers, pesticides, etc.) based on soil properties. This promotes efficient resource utilization, reduces environmental impacts, and maximizes crop yield.
- 7. Decision Support Systems: Crop prediction models based on soil properties can be integrated into decision support systems. These systems provide farmers with real-time information and recommendations for optimizing crop management practices. By considering soil properties in these systems, farmers can make data-driven decisions, enhancing productivity and sustainability.

Overall, crop prediction using soil properties has wide-ranging applications, enabling farmers to make informed decisions, optimize resource utilization, and improve agricultural practices. By leveraging soil data, farmers can enhance crop selection, yield prediction, nutrient management, irrigation practices, and soil health assessment, leading to increased productivity, sustainability, and profitability in agriculture.

VII Conclusion

In conclusion, crop prediction using soil properties is a valuable approach in modern agriculture. By analysing soil characteristics such as nutrient content, pH levels, organic matter content, soil texture, and moisture levels, farmers and agronomists can make informed decisions regarding crop selection, nutrient management, irrigation practices, and soil amendments. Integrating advanced techniques like machine learning and data integration enhances the accuracy of crop predictions and enables optimized agricultural practices.

By combining soil analysis, data collection, feature selection, model development, and evaluation, accurate crop predictions can be made based on the relationship between soil properties and crop performance. The utilization of trained models allows for making predictions about future crop yields or crop suitability based on specific soil properties and environmental conditions.

The benefits of crop prediction with soil properties are manifold. Farmers can optimize resource utilization, enhance productivity, and reduce environmental impacts by selecting crops that are best suited to the soil conditions. Precision agriculture practices can be implemented, minimizing fertilizer and water usage while maximizing crop yield. Additionally, this approach enables farmers to make informed decisions regarding soil management practices and implement targeted interventions to address soil deficiencies or imbalances.

VIII. REFERENCES

- 1. https://www.tandfonline.com/doi/full/10.1080/13873954.2021.1882505
- 3. https://ieeexplore.ieee.org/iel7/9844268/9844270/09844274.pdf
- 4. <u>https://eecs.ku.edu/crop-prediction-based-soil-classification-using-machine-learning-</u> classifier-ensembling
- 5. https://ijarsct.co.in/Paper1040.pdf
- 6. <u>https://easychair.org/publications/preprint_open/BhBS</u>
- 7. <u>https://www.researchgate.net/publication/357759181_Crop_prediction_using_machine_lear_ning</u>
- 8. <u>https://www.scribd.com/document/601287230/CROP-PREDICTION-SYSTEM-FINAL-REPORT-1</u>