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Study of MCDM Technology for Soil Fertility Analysis

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Abstract — Soil fertility is a critical factor in agricultural productivity and sustainable land management. Traditional methods of assessing soil health often rely on a limited set of parameters, which may not comprehensively represent the complexity of soil ecosystems. To address this limitation, our project proposes the use of Multicriteria Decision-Making (MCDM) techniques to enhance soil fertility analysis. The project incorporates multiple factors that influence soil fertility, including nutrient content, pH, organic matter, moisture, and soil structure. By employing MCDM techniques, we aim to develop a robust framework that integrates these diverse parameters to generate a comprehensive soil fertility index. This index will serve as a valuable tool for farmers, agronomists, and land management professionals, providing them with a more holistic understanding of soil health. Our approach involves a combination of data collection, parameter weighting, and decision-making algorithms. By engaging stakeholders in the agricultural sector, we ensure that the criteria and weightings reflect real-world priorities and conditions. Through a case study, we demonstrate the effectiveness of our MCDM-based method in assessing soil fertility and guiding agricultural practices. The results indicate that our MCDM approach offers a more flexible and nuanced analysis compared to traditional methods. It allows users to adjust weightings according to specific goals or regional considerations, facilitating tailored recommendations for soil improvement. The project concludes with a discussion on the broader implications for sustainable agriculture and potential areas for further research. Our project underscores the importance of adopting a multidimensional perspective in soil fertility analysis, contributing to improved agricultural productivity and sustainable land management. The MCDM technique, with its capacity to integrate complex data sets and accommodate diverse stakeholder inputs, has the potential to become a standard tool in soil health assessment.

KEY WORDS – Soil Fertility, Artificial Intelligence And Machine Learning Algorithms, Image Identification, Numpy, Pandas.

I.INTRODUCTION

Agriculture is at the heart of human civilization, providing food, raw materials, and employment. With the global population steadily increasing, the pressure on agricultural systems to produce more, while maintaining sustainability, is greater than ever. One key to meeting this challenge is optimizing soil fertility, a critical factor in crop production. Traditional soil analysis methods, often reliant on a limited set of parameters, fall short of providing a comprehensive understanding of soil health. This project seeks to bridge that gap by employing Multicriteria Decision-Making (MCDM) techniques for a more holistic approach to soil fertility analysis. The MCDM framework is designed to handle complex decision-making scenarios where multiple factors must be considered simultaneously. In the context of soil fertility, this means integrating a wide array of parameters such as nutrient levels, pH balance, organic matter content, soil structure, moisture, and more. Our approach creates a soil fertility index that reflects the nuanced interplay of these elements, offering farmers and agronomists a comprehensive tool for assessing soil health and making informed decisions about crop management .A core feature of this project is its emphasis on adaptability and customization. Soil fertility can vary widely based on location, climate, and cropping practices, requiring flexible analysis tools. MCDM allows us to assign different weights to various parameters, depending on their importance in specific contexts. This adaptability ensures that the soil fertility index generated by our system can be tailored to meet the unique needs of different agricultural settings. Beyond soil fertility analysis, our project includes additional features designed to provide comprehensive support for agricultural decision-making. One such feature is crop disease prediction. Using advanced data analytics, our system can detect patterns in soil and environmental conditions that may signal an increased risk of certain crop diseases. This predictive capability enables farmers to implement preventive measures, reducing the likelihood of disease outbreaks and minimizing crop losses. Another critical feature is fertilizer recommendation. Proper fertilizer use is essential for maintaining soil fertility and promoting healthy crop growth. However, overuse or improper application can lead to nutrient imbalances and environmental degradation. Our MCDM-based system generates fertilizer recommendations that are customized to the specific needs of the soil and the crops being grown. This tailored approach helps farmers optimize fertilizer use, thereby reducing waste and promoting more sustainable practices. The inclusion of these features underscores the holistic nature of our project. By integrating soil fertility analysis with crop disease prediction and fertilizer recommendations, we offer a comprehensive solution that addresses the interconnected challenges faced by modern agriculture. This approach not only improves crop productivity but also contributes to sustainable land management and environmental protection. In summary, this project aims to revolutionize soil analysis by using MCDM techniques to create a robust soil fertility index, while also incorporating predictive analytics for crop diseases and tailored fertilizer recommendations. The ultimate goal is to empower farmers and agronomists with the tools they need to make informed decisions, leading to increased agricultural productivity and sustainability..

II.LITERATURE SURVEY

Agriculture is a vital component of global food security and economic sustainability. As the world's population continues to grow, the need for efficient and sustainable agricultural practices has never been greater. Soil fertility, a key determinant of crop yield and quality, plays a crucial role in agricultural success. This literature review explores current methodologies for soil fertility analysis, with a focus on Multicriteria Decision-Making (MCDM) techniques, as well as related features such as crop disease prediction and fertilizer recommendations. Historically, soil fertility analysis has relied on straightforward measurements of key soil properties like pH, nutrient content, and organic matter. Works such as those by Brady and Weil (2016) discuss these conventional techniques, emphasizing their importance in basic soil assessment. However, traditional approaches often lack the depth needed to fully understand the complex interactions within soil ecosystems. They tend to focus on individual components without considering the broader context of soil health. The limitations of these traditional methods have led researchers to seek more comprehensive approaches. Studies such as those by Blume et al. (2016) suggest that a more holistic perspective is needed to accurately assess soil fertility. This requires analyzing a broader range of factors, including soil structure, microbial activity, and moisture dynamics. The demand for a more comprehensive approach has driven the development of new methodologies that can better capture the complexity of soil ecosystems. Multicriteria Decision-Making (MCDM) is an analytical framework designed to handle complex decision-making scenarios involving multiple factors. Its application in agriculture has gained momentum due to its flexibility and capacity to incorporate a diverse set of criteria. In soil fertility analysis, MCDM allows researchers to consider various parameters simultaneously, providing a more nuanced understanding of soil health. In agriculture, MCDM has been used to solve a range of problems, from crop selection and irrigation management to land use planning. Research by Kabak and Dagdeviren (2014) highlights the benefits of MCDM in agricultural contexts, showing how it can help balance conflicting objectives. For soil fertility analysis, MCDM offers a valuable tool for integrating multiple factors into a cohesive decision-making process. This flexibility makes it an ideal approach for addressing the complexities of soil fertility. Crop diseases pose a significant threat to agricultural productivity and food security. Traditional methods of disease prediction often rely on visual inspections and historical trends, which can be imprecise and prone to human error. The advent of data analytics and machine learning has opened new avenues for predictive modeling in agriculture. Studies like those by Singh et al. (2021) and Liakos et al. (2018) explore the use of machine learning to predict crop diseases based on soil conditions, weather patterns, and other relevant data. These studies demonstrate that data-driven approaches can improve the accuracy of disease prediction, allowing farmers to take proactive measures to prevent or mitigate crop disease outbreaks. By integrating predictive analytics with soil fertility analysis, it is possible to create a more comprehensive system that not only assesses soil health but also anticipates potential risks. Fertilizer management is a critical aspect of sustainable agriculture. Overuse or improper application of fertilizers can lead to nutrient imbalances, soil degradation, and environmental pollution. Traditional approaches to fertilizer recommendations often focus on soil nutrient levels and basic crop requirements. However, a one-size-fits-all approach is often ineffective due to the variability in soil properties and crop needs .Recent studies, such as those by Zhang et al. (2019) and Roy et al. (2006), emphasize the importance of tailored fertilizer recommendations. These approaches consider a broader range of factors, including soil nutrient content, crop type, growth stage, and environmental conditions. By using MCDM, researchers can create fertilizer recommendation systems that are customized to specific scenarios, ensuring optimal nutrient application and reducing waste. The literature points to a growing interest in integrated approaches to soil fertility analysis. Researchers are exploring how a combination of techniques can lead to more comprehensive solutions for agriculture. For instance, Rodrigues et al. (2020) suggest that integrating soil fertility analysis with irrigation management and crop disease prediction can lead to improved agricultural practices. This integrated approach aligns with the goals of our project, which aims to combine MCDM-based soil fertility analysis with crop disease prediction and tailored fertilizer recommendations. The integrated approach has several advantages. It allows for a more holistic understanding of soil health, considers potential risks from crop diseases, and provides specific recommendations for nutrient management. This comprehensive view is critical for developing sustainable agricultural practices that can meet the demands of a growing global population while minimizing environmental impact. The literature review reveals a trend toward more comprehensive approaches to soil fertility analysis. Multicriteria Decision-Making (MCDM) techniques offer a flexible framework for integrating multiple criteria, providing a more holistic view of soil health. The addition of features like crop disease prediction and tailored fertilizer recommendations enhances the potential for effective agricultural decision-making. These insights inform the design and objectives of our project, emphasizing the need for a multidimensional approach to soil fertility analysis. By combining MCDM with predictive analytics and customized fertilizer recommendations, we aim to create a robust system that addresses the complexities of modern agriculture. As we continue to develop our approach, we anticipate contributing to the ongoing effort to improve agricultural productivity and sustainability.

III.PROPOSED METHODOLOGY

Developing an advanced framework for soil fertility analysis requires a holistic approach that integrates multiple factors influencing soil health and agricultural productivity. Our proposed methodology merges Multicriteria Decision-Making (MCDM) techniques with predictive analytics for crop disease and tailored fertilizer recommendations, providing a comprehensive decision support system for farmers and agronomists. Data Collection and Preparation The first phase of our methodology is data collection, which forms the foundation for all subsequent analysis. We begin by collecting soil samples from various locations within the targeted agricultural region. Sampling must cover different soil types and areas to ensure representative data. Techniques such as grid sampling or random sampling are utilized to achieve a comprehensive data set. These samples are then analyzed in a laboratory to measure chemical properties like nutrient levels (nitrogen, phosphorus, potassium), pH, organic matter, and physical properties such as soil texture and structure. Additionally, biological indicators, including microbial activity, are assessed to gain insight into soil health. Environmental data is also gathered as part of this phase. Information on temperature, humidity, rainfall, wind patterns, and other climate-related factors is crucial for understanding broader influences on soil fertility and predicting potential crop disease risks. This comprehensive dataset allows for a robust analysis of soil fertility and related factors. Application of Multicriteria Decision-Making (MCDM) Techniques With the data in hand, we proceed to apply MCDM techniques to create a soil fertility index. The MCDM framework is ideal for this purpose because it can handle complex decision-making scenarios involving multiple criteria. The first step is selecting relevant criteria for the analysis. Given the collected data, we identify key factors such as nutrient levels, pH, organic matter, moisture, and soil structure that play significant roles in determining soil fertility Once the criteria are selected, we assign weights to each based on their relative importance. This weighting is crucial, as it allows for flexibility in adapting the analysis to different contexts and objectives. Input from stakeholders—farmers, agronomists, and soil scientists—helps determine appropriate weightings to ensure that the MCDM process accurately reflects real-world conditions. Next, we apply an MCDM algorithm to generate the soil fertility index. Common algorithms include the Analytic Hierarchy Process (AHP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), and Weighted Sum Model (WSM). These algorithms calculate a composite score for each sample, representing its overall soil fertility. The resulting index is then used to categorize soil into different fertility levels, providing a clear guide for agricultural practices. Predictive Analytics for Crop Disease The integration of predictive analytics for crop disease is a key component of our proposed methodology. By analyzing the environmental data alongside soil properties, we can develop a model that predicts the likelihood of crop diseases. This predictive capability is invaluable for farmers, allowing them to take preventive measures to reduce crop losses and optimize their agricultural practices. To build the predictive model, we employ machine learning techniques such as decision trees, random forests, or neural networks. These algorithms can identify patterns and correlations between environmental conditions, soil health, and the occurrence of crop diseases. The model is trained using historical data on crop diseases and validated against known outcomes to ensure accuracy. Once the model is validated, it is integrated into the broader framework. This integration allows farmers to assess both soil fertility and crop disease risks, providing a comprehensive view of the factors influencing crop health. By addressing potential disease risks early, farmers can take proactive steps to mitigate damage, leading to improved productivity and sustainability. Tailored Fertilizer Recommendations Fertilizer management is crucial for maintaining soil fertility and promoting sustainable agricultural practices. Our methodology incorporates a tailored approach to fertilizer recommendations, leveraging the MCDM-derived soil fertility index and specific crop requirements. A fertilizer recommendation model is developed to provide customized suggestions based on the soil fertility index, crop type, growth stage, and nutrient needs. This tailored approach ensures that fertilizer application is optimized for each unique scenario, reducing the risk of over- or under-fertilization. The model is calibrated and validated to ensure its accuracy, with adjustments made as needed to account for variations in soil properties and environmental conditions. Once the model is validated, farmers can use it to guide fertilizer application, ensuring optimal nutrient use and reducing environmental impact. This approach not only promotes soil health but also contributes to sustainable agricultural practices. Comprehensive Agricultural Decision Support System The final step in our proposed methodology is integrating all components into a comprehensive agricultural decision support system. This system provides a user-friendly interface that allows farmers and agronomists to access the soil fertility index, crop disease predictions, and tailored fertilizer recommendations. The user interface is designed to be intuitive and accessible, with graphical representations that make complex data easy to understand. The system allows users to input data, view results, and receive actionable recommendations, making it a valuable tool for agricultural decision-making. To ensure successful implementation, training sessions are conducted to familiarize farmers and agronomists with the system's features and functionalities. Ongoing support is also provided to address any issues and gather feedback for continuous improvement. This comprehensive approach aims to empower farmers with the knowledge and tools needed to improve crop productivity, enhance soil health, and promote sustainable agricultural practices.

Fig 1 System Architecture

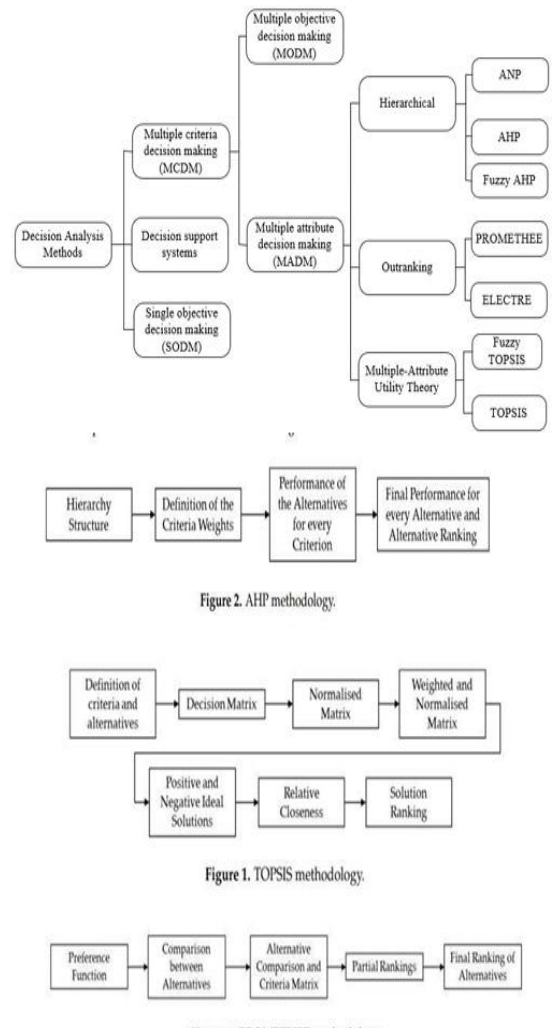


Fig 2 Front-End Interface

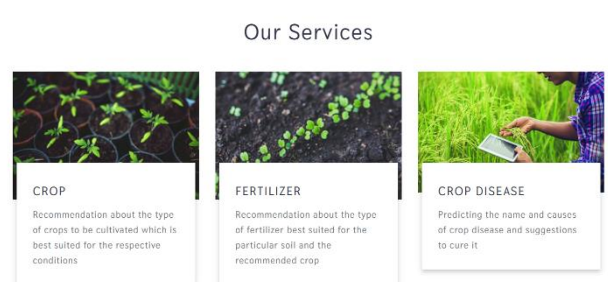


Fig 3 Crop Recommendation System

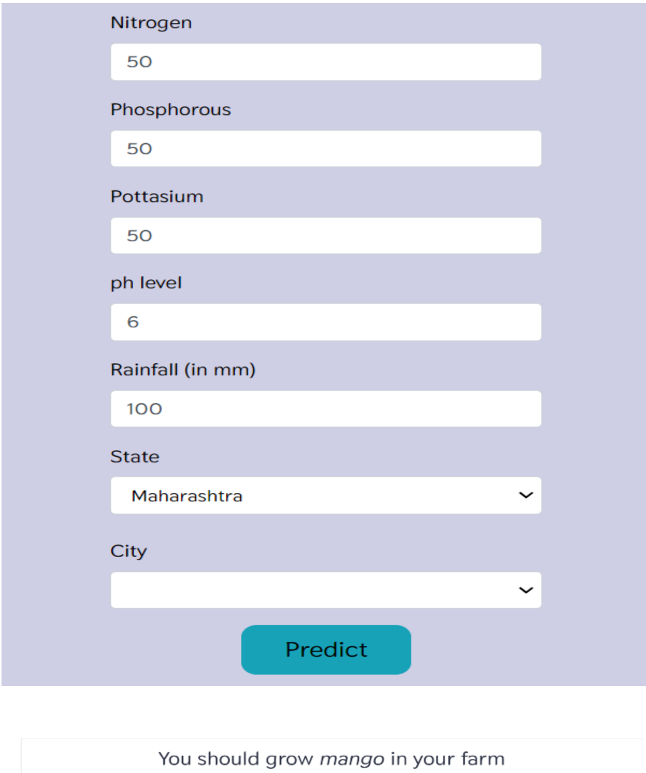
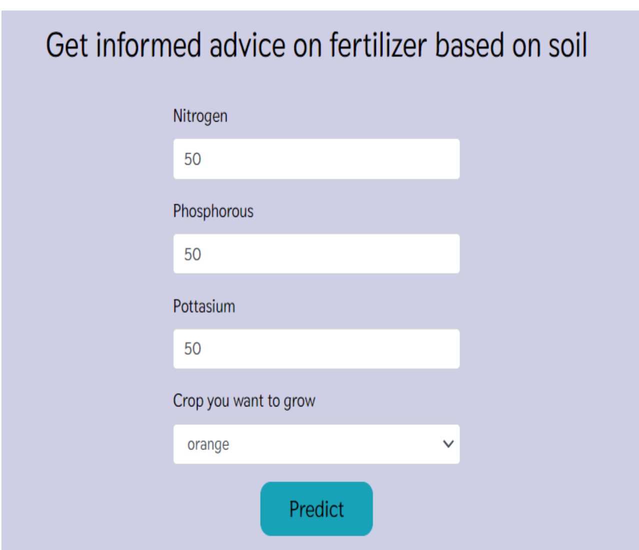
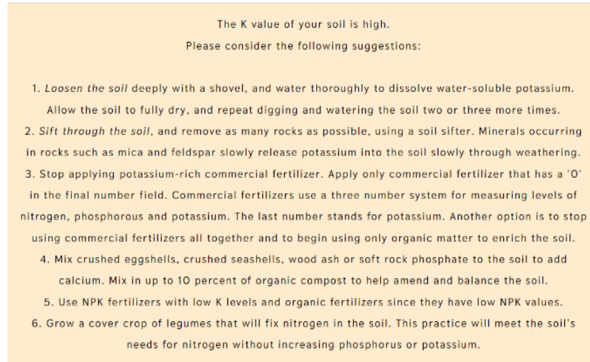


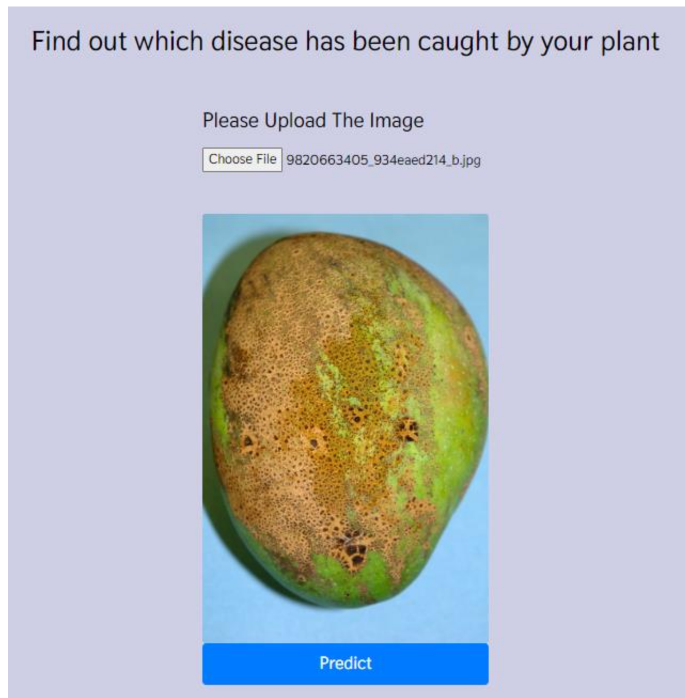
Fig 3 Soil Fertility Recommendation




The K value of your soil is high.
Please consider the following suggestions:

1. *Loosen the soil* deeply with a shovel, and water thoroughly to dissolve water-soluble potassium. Allow the soil to fully dry, and repeat digging and watering the soil two or three more times.
2. *Sift through the soil*, and remove as many rocks as possible, using a soil sifter. Minerals occurring in rocks such as mica and feldspar slowly release potassium into the soil slowly through weathering.
3. Stop applying potassium-rich commercial fertilizer. Apply only commercial fertilizer that has a '0' in the final number field. Commercial fertilizers use a three number system for measuring levels of nitrogen, phosphorous and potassium. The last number stands for potassium. Another option is to stop using commercial fertilizers all together and to begin using only organic matter to enrich the soil.
4. Mix crushed eggshells, crushed seashells, wood ash or soft rock phosphate to the soil to add calcium. Mix in up to 10 percent of organic compost to help amend and balance the soil.
5. Use NPK fertilizers with low K levels and organic fertilizers since they have low NPK values.
6. Grow a cover crop of legumes that will fix nitrogen in the soil. This practice will meet the soil's needs for nitrogen without increasing phosphorus or potassium.

Fig 3 Disease Detection System



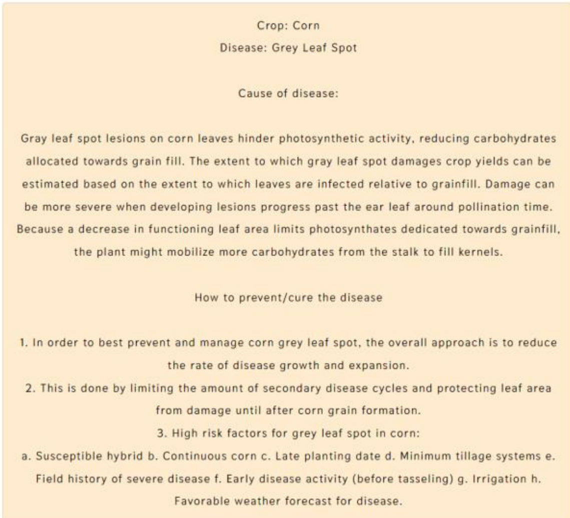


Fig1 focuses on architecture used in order to construct the system. It consist of multiple such as AHP methodology which is used to create the website. Fig 2 focuses on the front end of the website which consist of three main components which are crop recommendation system, soil fertility recommendation system and disease detection system.[1]Crop recommendation system works through data that is already present in the stored dat. The user have to input components such as nitrogen, phosphorous, potassium, ph level, rainfall, state and city in order to predict the crop which can be grown in the certain area.[2]The soil fertility system is similar to crop recommendation system which helps to predict if the soil is fertile in order to cultivate a certain crop. the user inputs the nitrogen level, potassium level , phosphorous and crop which needs to be cultivated on the ground.[3] The disease detection system works by scanning a picture of a crop which is been damaged in order to detect the disease the crop is carrying. It also recommends ways through which user can cope with the situation.[4]This is the working of the website.

IV.CONCLUSION

The proposed methodology for soil fertility analysis using Multicriteria Decision-Making (MCDM) techniques, along with crop disease prediction and tailored fertilizer recommendations, represents a significant step forward in agricultural decision-making. This comprehensive approach allows for a holistic understanding of soil health, taking into account a range of factors that influence soil fertility and crop productivity.[1]By leveraging MCDM, we can integrate multiple criteria into a single framework, providing a robust soil fertility index that reflects the complex dynamics of soil ecosystems. The inclusion of predictive analytics for crop disease enhances this approach, enabling early identification of potential risks and allowing farmers to take proactive measures to protect their crops. The tailored fertilizer recommendations, based on the MCDM-derived soil fertility index and specific crop requirements, ensure optimal nutrient management, reducing waste and promoting sustainability.[2]The comprehensive agricultural decision support system that integrates these components offers a user-friendly interface for farmers and agronomists, allowing them to make informed decisions about soil fertility, crop disease prevention, and fertilizer management. This system provides a practical tool for improving agricultural practices, enhancing crop yields, and promoting sustainable use of resources.[3]Overall, the proposed methodology has the potential to significantly impact agricultural productivity and sustainability. By adopting a comprehensive approach to soil fertility analysis and related agricultural practices, farmers can achieve better results while minimizing environmental impact. The methodology's flexibility allows for adaptation to different contexts, making it applicable to a wide range of agricultural settings.[4]As agriculture continues to evolve to meet the demands of a growing global population, innovative approaches like the one outlined in this project will play a crucial role in ensuring food security and sustainability. Our proposed methodology lays the groundwork for future advancements in soil fertility analysis and serves as a model for integrating multiple aspects of agricultural decision-making into a cohesive and effective system.[5]

V.FUTURE SCOPE

The proposed methodology for soil fertility analysis, which integrates Multicriteria Decision-Making (MCDM) techniques with crop disease prediction and tailored fertilizer recommendations, offers a comprehensive framework for sustainable agricultural decision-making.[1]In the future, this methodology can be further developed through the integration of advanced technologies like IoT, remote sensing, and drones, allowing for real-time monitoring and large-scale data collection. [2]Additionally, the approach can be customized for various crops, regions, and climates to address specific agricultural challenges. Improved predictive analytics for crop diseases, incorporating sophisticated machine learning algorithms and genomic data, will enhance the accuracy of disease prevention. [3]This methodology can also integrate with broader agricultural management practices, such as irrigation and crop rotation planning, to create holistic farm management solutions. Collaboration among researchers, industry experts, and agricultural stakeholders will foster innovation and knowledge sharing, while environmental impact assessments will ensure sustainable practices. [4]Finally, economic analyses and cost-benefit studies will demonstrate the financial benefits of this approach, encouraging adoption across different agricultural sectors. [5]By focusing on continuous improvement and adaptation to evolving agricultural trends, this methodology aims to support a more sustainable, efficient, and productive agricultural future.

VI.REFERENCES

[1] Krutika Hampannavar, Vijay Bhajantri, Shashikumar G. Totad "Prediction of Crop Fertilizer Consumption," Fourth International Conference on Computing Communication Control and Automation (ICCUBEA),2018, PP.1-5

[2] G. Prabakaran, D. Vaithiyanathan, Madhavi Ganesa, "Fuzzy decision support system for improving the crop productivity and efficient use of fertilizers," Computers and Electronics in Agriculture, vol-150, 2018, PP. 88-97

[3] Shital Bhojani, Nirav Bhatt, "Data Mining Techniques for Crop Yield Prediction," Computers and Electronics in Agriculture, vol- 6, 2018, PP. 357-358

[4] Yulong Yin, Hao Ying, Huifang Zhen, Q ingsong Zhang, Y anfang Xue, Zhenling I, "Estimation of NPK requirements for rice production in diverse Chinese environments under optimal fertilization rate," Agricultural and Forest Meteorology, vol-279, 2019, PP. 1-6

[5] Laura J.T. Hess, Eve-Lyn S. Hinckley, G. Philip Robertson, Pamela A. Matson, "Rainfall intensification increases nitrate leaching from tilled but not no-till cropping systems in the U.S. Midwest," Agriculture, Ecosystems & Environment, vol-290, 2020, PP. 1-10

[6] Potnuru Sai Nishant,Pinapa Sai Venkat,Bollu Lakshmi Avinash,B. Jabber, "Crop Yield Prediction Based on Indian Agriculture using Machine Learning," 2020 International Conference for Emerging Technology (INCET), 2020, PP. 1-4

[7] Tony Yang, Kadambot H.M., Siddique, Kui Liu, "Cropping systems in agriculture and their impact on soil health," Global Ecology and Conservation, vol-23, year, PP. 1-13

[8] János Kátai, Ágnes Oláh Zsuposné, Magdolna Tállai, Tarek Alshaal, "Would fertilization history render the soil microbial communities and their activities more resistant to rainfall fluctuations? ," Ecotoxicology and Environmental Safety, vol-201, 2020, PP. 1-11

[9] Usman Ahmed, Jerry Chun-Wei Lin, Gautam Srivastava, Youcef Djenouri, "A nutrient recommendation system for soil fertilization based on Evolutionary Computation," Computers and Electronics in Agriculture, vol-189, 2021, PP. 1-7

[10] A.Hussein, Diogenes L. Antille, Shreevatsa Kodur, GuangnanChen, Jeff N.Tullberg, "Controlled traffic farming effects on productivity of grain sorghum, rainfall and fertilizer nitrogen use efficiency," Journal of Agriculture and Food Research, vol-3, 2021, PP. 1-17

[11] Zujiao Shi, Donghua Liu, Miao Liu, Muhammad Bilal Hafeez, Pengfei Wen, Xiaoli Wang, Rui Wang, Xudong Zhang, Jun Li, "Optimized fertilizer recommendation method for nitrate residue control in a wheat–maize double cropping system in dryland farming," Field Crops Research, vol-271, 2021, PP. 1-10

[12] Janmejay Pant, R.P. Pant, Manoj Kumar Singh, Devesh Pratap Singh, Himanshu Pant, "Analysis of agricultural crop yield prediction using statistical techniques of machine learning," Materials Today: Proceedings, vol-46, 2021, PP. 1-10

[13] Benny Antony, "Prediction of the production of crops with respect to rainfall.," Environmental Research, vol-202, 2021, PP. 1-5

[14] Akash Manish Lad, K. Mani Bharathi, B. Akash Saravanan, R. Karthik, "Factors affecting agriculture and estimation of crop yield using supervised learning algorithms," Materials Today: Proceedings, 2022, PP. 1-10

[15] Raves Akhtar, Shabbir Ahmad Sofi, "Precision agriculture using IoT data analytics and machine learning," Journal of King Saud University - Computer and Information Sciences, 2021, PP. 1-17

[16] Saheed Garnaik, Prasanna Kumar Samant, Mitali Mandal, Tushar Ranjan Mohanty, Sanat Kumar Dwibedi, Ranjan Kumar Patra, Kiran Kumar Mohapatra, R.H. Wanjari, Debadatta Sethi, Dipaka Ranjan Sena, Tek Bahadur Sapkota, Jagmohan Nayak, Sridhar Patra, Chiter Mal Parihar, Hari Sankar Nayak, "Untangling the effect of soil quality on rice productivity under a 16-years long-term fertilizer experiment using conditional random forest," Computers and Electronics in Agriculture, vol-197,2022, PP. 1-10

[17] Rubby Aworka, Lontsi Saadio Cedric, Wilfried Yves Hamilton Adoni, Jérémie Thouakesseh Zoueu, Franck Kalala Mutombo, Charles Lebon Mberi Kimpolo, Tarik Nahhal, Moez Krichen, "Agricultural decision system based on advanced machine learning models for yield prediction: Case of East African countries," Smart Agricultural Technology, vol-3, 2022, PP. 1-9

[18] Senthil Kumar Swami Durai, Mary Divya Shamili, "Smart farming using Machine Learning and Deep Learning techniques," Decision Analytics Journal, vol-2, 2022, PP. 1-30

[19] M.S. Suchithra, Maya L. Pai, "Improving the prediction accuracy of soil nutrient classification by optimizing extreme learning machine parameters," Information Processing in Agriculture, vol-7, 2022, PP. 1-11

[20]Kaggle,"https://www.kaggle.com/datasets/atharvaingle/crop-recommendation-dataset " (accessed on 16th November 2021