# Smart Fertilizer Recommendation System

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**Abstract**

Over half of the world's population relies on agriculture for their income, which makes agriculture one of mankind's most important industries. Crops have been grown on the same land for thousands of years without the appropriate knowledge of soil depletion and rejuvenation. The nutrients present in the soil directly affect the crop production quality and quantity. There is also a high chance of plant diseases and infections rising because of the insufficiency or sufficiency of soil nutrients. Excessive use of Fertilizers and Pesticides can also result in crop damage and land pollution which may rise into food diseases. Understanding the need for the importance of right use of fertilizers in the right geographical location is high. Farmers can increase crop growth by determining soil and environment conditions as they transition from the wet season to the dry season.

This project aims to find and recommend the most suitable fertilizer for the given crop based on the parameters such as moisture, humidity, temperature, and nitrogen, potassium, and phosphorus levels. Usage of multiple Sensors (Moisture Sensor, Temperature Sensor, NPK Sensor, etc.) will be done to get the data from soils in different regions. A region-wise Fertilizer Recommendation System will be proposed to the farmer by inputting multiple parameters mentioned above. The farmer will be able to interact with this system through a website.

To reduce the lack of experts, assist and help the rural farmers, an intelligent and easy to use machine learning based fertilizer recommendation system is developed. This work proposes a Machine Learning based fertilizer recommendation system

*Keywords*: AI, ML, IoT, SVM, RF, KNN, NPK

## 1. Introduction

Agriculture plays a very vital role in everyone's life since agriculture provides most of the world's food and fabric. Smart farming has become a need of an hour and play a very vital role in agriculture monitoring the growth of crop, monitoring soil moisture, soil temperature, soil fertility, prediction of fertilizers etc. Smart farming involves sensors, Internet of thing (IOT), Artificial Intelligence, Big Data, Cloud Computing and machine learning algorithms which help in improving the crop yield. Smart farming also can be used for recommending right fertilizer.

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Fertilizers are essential for plant growth because they are used to supply essential nutrients such as nitrogen, phosphorus, and potassium. However, the excessive use of fertilizers can lead to environmental pollution, soil degradation, and human health problems. In recent years, the use of fertilizers has increased significantly due to the increasing demand for food production to feed the growing population. Hence, it is necessary to develop an efficient fertilizer recommendation system that can provide farmers with optimal fertilizer usage.

In this research we have developed a system that can predict a correct fertilizer depending on input values Temperature, Humidity, Soil type, Nitrogen(N), Phosphorous(P), Potassium(K), and Fertilizer Type

## 2. Materials and Methods

The paper discusses the potential of using Internet of Things (IoT) technology in agriculture to address challenges faced by farmers such as climate change, water scarcity, and land degradation. The authors highlight the importance of precision agriculture, enabled by data from sensors, in making more informed decisions about crop management. The paper provides examples of IoT-based applications in agriculture, such as smart irrigation and crop monitoring systems, and emphasizes the importance of data analytics in making sense of the large amounts of data generated by IoT sensors. Overall, the paper suggests that the use of IoT technology in agriculture can help improve the efficiency and productivity of agricultural practices and address global challenges such as food security and sustainability.[1]. The paper discusses the architecture of the future Internet of Things (IoT) and compares it to the neural system of mankind or a social organization framework. The authors suggest that the architecture of the future IoT should be designed to have self-organizing, self-configuring, and self-healing capabilities, similar to the neural system of mankind. They also propose that the future IoT should be able to dynamically adapt to changing environments and support ubiquitous connectivity and context-awareness. The authors suggest that the future IoT architecture should be designed to support a social organization framework, where devices can collaborate and communicate with each other to achieve common goals. Overall, the paper emphasizes the importance of a well-designed IoT architecture that can support the complex requirements of the future IoT ecosystem.[2]. The paper discusses the design of an intelligent agriculture management information system based on Internet of Things (IoT) technology. The author highlights the importance of information management in agriculture and the potential benefits of using IoT technology in agriculture. The paper presents the architecture of the proposed system, which includes sensor nodes, a wireless sensor network, a data center, and a decision-making system. The paper also discusses the implementation of the system and its potential benefits, including improved crop yields, reduced labor costs, and more efficient use of resources. Overall, the paper suggests that an intelligent agriculture management information system based on IoT technology has great potential for improving the efficiency and productivity of agricultural practices.[3].

The paper discusses the use of sensor networks to connect agriculture to the Internet of Things (IoT). The authors highlight the potential benefits of using IoT technology in agriculture, such as improving crop yields, reducing resource waste, and increasing efficiency. The paper presents the design and implementation of a sensor network-based IoT system for agriculture, which includes sensor nodes, a data collection and transmission module, and a cloud-based data analysis platform. The paper also discusses the results of field tests conducted to evaluate the system's performance and effectiveness. Overall, the paper suggests that sensor network based IoT systems have great potential for improving agricultural practices by providing real-time data and recommendations to farmers.[4]. The paper discusses an IoT application system with crop growth models in facility agriculture. The authors highlight the importance of precision agriculture in facility agriculture and the potential benefits of using IoT technology to optimize crop growth. The paper presents the design and implementation of an IoT system that includes a wireless sensor network, a data acquisition module, a crop growth model, and a decision support system. The system is designed to collect data from sensors in the facility, such as temperature, humidity, and light intensity, and use this data to simulate crop growth and provide recommendations for optimizing crop growth. The paper also discusses the results of field tests conducted to evaluate the system's performance and effectiveness. Overall, the paper suggests that IoT-based systems with crop growth models have great potential for improving the efficiency and productivity of facility agriculture practices.[5]. The paper discusses the research on an agriculture intelligent system based on IoT. The author emphasizes the importance of information technology in agriculture and the potential benefits of using IoT technology to optimize agricultural practices. The paper presents the architecture and implementation of an IoT-based agriculture intelligent system, which includes a wireless sensor network, a data acquisition and transmission module, and a cloud-based decision-making system. The system is designed to collect data from sensors in the field, such as temperature, humidity, and soil moisture, and use this data to provide recommendations for optimizing crop growth and reducing resource waste. The paper also discusses the results of field tests conducted to evaluate the system's performance and effectiveness. Overall, the paper suggests that an agriculture intelligent system based on IoT technology has great potential for improving the efficiency and productivity of agricultural practices.[6]. The paper is a guest editorial introducing a special issue on the IoT. The authors discuss the increasing importance of IoT technology and its potential impact on various industries, including healthcare, transportation, and energy. The paper highlights the main challenges in IoT technology, such as interoperability, security, and privacy, and emphasizes the need for standardized protocols and architectures. The authors also introduce the articles included in the special issue, which cover various topics related to IoT technology, including communication protocols, energy efficiency, and data processing. Overall, the paper provides an overview of the current state of IoT technology and highlights the importance of continued research and development in this area.[7]. The paper discusses the integration of IoT and cloud computing in the automation of assembly modeling systems. The authors highlights the importance of automation in the manufacturing industry and the potential benefits of using IoT and cloud computing to optimize the manufacturing process. The paper presents the design and implementation of an IoT-based assembly modeling system that utilizes cloud computing for data processing and analysis. The system is designed to collect data from sensors in the assembly line and use this data to optimize the assembly process in real-time. The paper also discusses the results of experiments conducted to evaluate the system's performance and effectiveness. Overall, the paper suggests that IoT and cloud computing can be effectively integrated to optimize the automation of assembly modeling systems and improve the efficiency and productivity of the manufacturing industry.[8]. The paper presents an agricultural production system based on the Internet of Things (IoT). The authors highlight the importance of IoT technology in the agricultural industry and the potential benefits of using IoT to optimize agricultural practices. The paper introduces the architecture and implementation of the IoT-based agricultural production system, which includes various sensors for monitoring environmental conditions, crop growth, and animal behavior. The system is designed to collect data from sensors in the field and use this data to provide recommendations for optimizing agricultural practices and improving crop yields. The paper also discusses the results of field tests conducted to evaluate the system's performance and effectiveness. Overall, the paper suggests that an IoT-based agricultural production system has great potential for improving the efficiency and productivity of agricultural practices, while reducing resource waste and environmental impact.[9] The paper proposes a framework to leverage cloud computing for modernizing the Indian agricultural system. The authors highlight the challenges facing the Indian agricultural system, including limited access to technology, lack of infrastructure, and inefficiencies in the supply chain. The paper suggests that cloud computing can be used to overcome these challenges by providing farmers with access to modern technology and enabling data sharing and collaboration throughout the supply chain. The proposed framework includes various components, such as cloud-based data storage and processing, mobile applications for farmers, and analytics tools for decision-making. The paper also discusses the benefits of the proposed framework, such as improved productivity, reduced costs, and increased transparency in the supply chain. The authors suggest that the proposed framework has great potential for modernizing the Indian agricultural system and improving the livelihoods of farmers.[10].

## 2.1 Proposed System

In this research we have developed a model that predicts rights fertilizer based on soil samples, crop information, weather data, and historical records. Following is the complete architecture of the complete system.

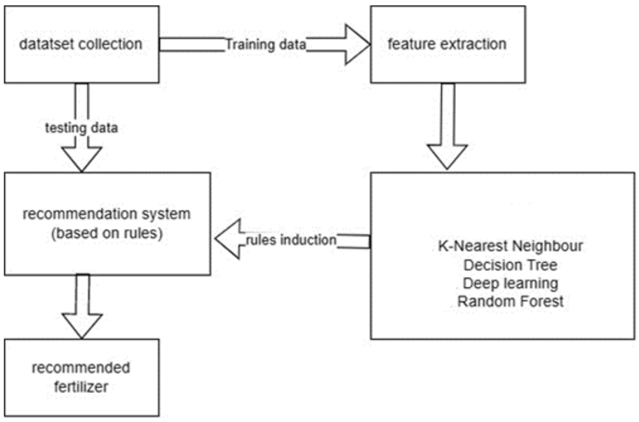


Figure 1 is the complete architecture of the proposed system.

Figure 1 describes the correlation between the user and the administrator. Also how the system would function as well as how the administrator would send the required inputs to the client side. The client will be able to see the status of the ongoing test, also if there are any vulnerabilities found, the user can see its severity and what would be the possible mitigations steps to eliminate the vulnerability and secure the asset.

## 2.2 Implementation

Following is the block diagram of the implemented systen

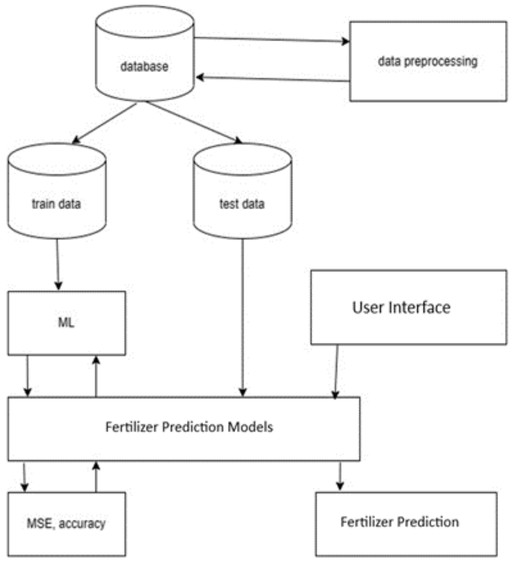


Figure 2 is the System Block diagram.

A. Dataset

The Fertilizer dataset is a collection of data that contains information about various features of crops and the corresponding fertilizer recommendation. The dataset is typically used in the domain of agriculture and aims to assist in determining the appropriate fertilizer type for different crops based on their characteristics. Dataset countains 9 columns and 99 rows.

Dataset include columns like Temperature, Humidity, Soil type, Nitrogen(N), Phosphorous(P), Potassium(K), and Ferilizer Type. Dataset has 9 columns and 99 rows.

B. Methodology

I. Random Forest Algorithm

Random Forest is a powerful and versatile algorithm that has found wide applications in various research domains. Its ability to handle complex datasets, robustness against overfitting, and interpretability make it a valuable tool for predictive modeling. Researchers continue to explore new techniques and advancements in Random Forest methodology to address challenges and enhance its performance. Accuracy for random forest algorithm was also highest for this specific project.

II. k-Nearest Neighbour (k-NN)

The KNN classifier is an algorithm that is used for both classification and regression. It makes predictions based on the proximity of the k nearest neighbors in the feature space. It creates multiple k values and assigns classes to different data points. This method used by KNN is classification method.

III. Support Vector Machine (SVM)

Support Vector Machine (SVM) is a supervised machine learning algorithm which can also be referred as SVC or SVR that is used for both classification and regression tasks. It is particularly effective in solving complex problems with high-dimensional feature spaces. SVM aims to find an optimal hyperplane or decision boundary that maximally separates the data points of different classes or predicts continuous values for regression.

IV. XGBoost Classifier

The XGBoost stands for eXtreme Gradient Boosting Classifier is a powerful ML algorithm that belongs to the gradient boost subset. It is a highly efficienct, scalable, and high predictive accuracy model. XGBoost combines multiple weak predictive models (typically decision trees) in an additive manner to create a strong ensemble model.

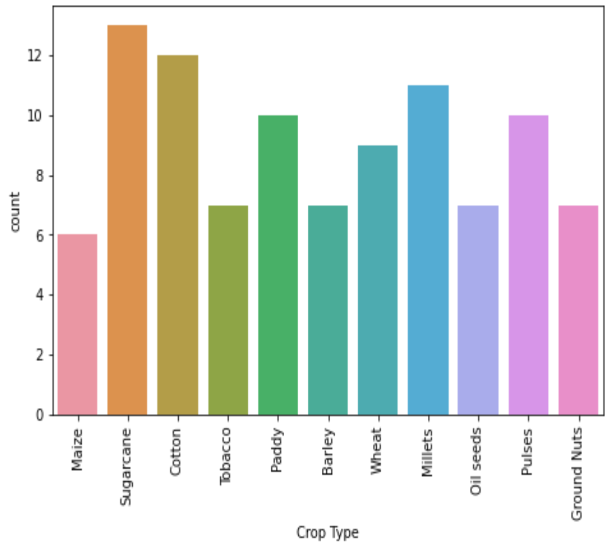


Figure 3: Count of types of Crops in the Dataset

## 3. Results and Discussion

This project was developed by enforcing four machine learning algorithms such as K Nearest Neighbor (k-NN), Support Vector Classification (SVM), Random Forest and XGBoost. For K Nearest Neighbor, we tested for multiple K values and found that the error was minimum for K=1 where Error = 0.065. SVM performed well with 93.54% accuracy on Test Data and 98.7% accuracy for whole data. Random Forest Algorithm gave an accuracy of 100% along with XGBoost being the same.

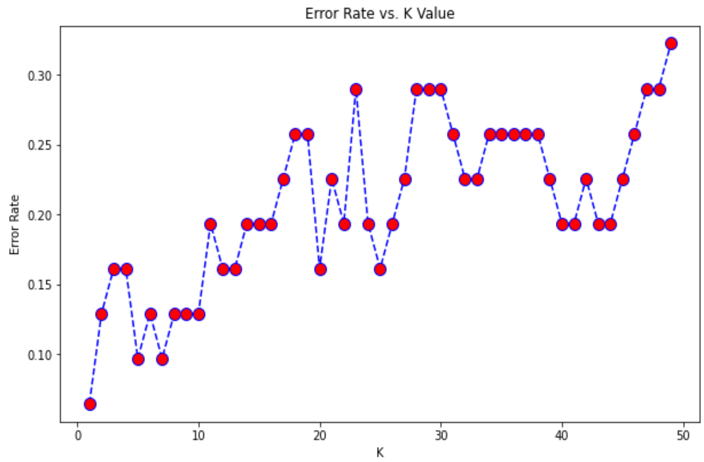


Figure 4: Error Rate for each K value in K Nearest Neighbour

## 3.1 Discussion

A fertilizer recommendation system is a software application that helps farmers determine the optimal type and amount of fertilizer to use for their crops. These systems use various data sources, such as soil samples, crop information, weather data, and historical records, to generate fertilizer recommendations that are tailored to the specific conditions of each farm.

The primary goal of a fertilizer recommendation system is to help farmers maximize their crop yields while minimizing the cost and environmental impact of fertilizer application. By using data-driven recommendations, farmers can avoid over-fertilization, which can lead to environmental problems such as nutrient runoff and soil degradation, while also reducing their fertilizer expenses.

Fertilizer recommendation systems generally use a combination of expert knowledge and machine learning algorithms to induce recommendations. Expert knowledge involves the use of agronomic models, soil testing, and crop-specific information to identify the applicable type and amount of fertilizer for the crops given.

The process of generating a fertilizer recommendation typically involves several steps. First, the system collects data about the soil, crop, and other relevant factors such as weather and pest pressure. This data is then preprocessed and analyzed to identify the appropriate features to use in the recommendation engine. The recommendation engine then generates a recommendation based on the identified features, using a combination of expert knowledge and machine learning algorithms. Finally, the recommendation is presented to the farmer in an easy-to-understand format, such as a mobile app or web interface.

Fertilizer recommendation systems have several benefits for farmers and the environment. By providing accurate and personalized recommendations, these systems can help farmers optimize their fertilizer use, reduce their costs, and increase their crop yields.
In conclusion, fertilizer recommendation systems are an essential tool for modern agriculture. By using data-driven recommendations, these systems can help farmers optimize their fertilizer use, increase their crop yields, and reduce their environmental impact. As technology continues to advance, the future of fertilizer recommendation systems looks promising, with more personalized and sustainable recommendations that can help farmers succeed in an

increasingly competitive and environmentally conscious world.

## 4. LIMITATIONS OF STUDY

There is a lot that comes into play when we consider the recommendation of fertilizers for a particular type of soil by considering multiple factors. In this study, we have implemented environmental factors such as temperature, soil moisture, humidity, etc. However, there are many more environmental conditions like sunlight and rainfall that should be considered. However, most research works concentrated on predicting the level of nutrients of NPK saturation to optimize the production. Many more parameters have not been considered which include the season, location and crop growing techniques used by farmers. Another limitation that needs to be considered is that the project displays a web User Interface which is simple and easy to use, however it can be difficult for farmers and agriculturists to use the system and get a hands-on experience. This situation may arise due to lack of technological knowledge and/or unable to read and understand a particular language

## 5. Conclusion

Smart farming is a rapidly growing field that utilizes innovative technologies such as Internet of Things, sensors, automation, and AI to optimize agricultural production. The use of these technologies has the potential to transform traditional farming practices, making them more efficient, cost-effective, and sustainable. The benefits of smart farming include increased crop yields, improved resource utilization, reduced labor costs, and better-quality control. Additionally, smart farming will reduce the environmental impact by minimizing the use of pesticides/fertilizers and conserving water resources.

While the relinquishment of smart husbandry technologies is still in its early stages, it's anticipated to grow significantly in the coming times as further growers realize the benefits of these technologies. However, there are also challenges that need to be addressed, similar as the high cost of some technologies, the need for training and support for growers, and enterprises around data sequestration and security. In conclusion, smart farming has the potential to bring a change in the agricultural industry, improving productivity, sustainability, and profitability. As technology continues to evolve, it is likely that smart farming will become an essential part of modern agriculture, contributing to a more sustainable and secure global food supply

### 5.1 Future Scope

The future scope of fertilizer recommendation systems is quite promising, and there are several areas where these systems can be improved and expanded upon. Here are a few examples:

Integration with Precision Agriculture: Precision agriculture is an emerging field that involves the use of advanced technologies such as sensors, drones, and satellite imagery to gather data about crops and soil. Fertilizer recommendation systems can be integrated with precision agriculture technologies to provide more accurate and timely recommendations based on real-time data.

Personalization: Currently, most fertilizer recommendation systems provide general recommendations based on crop and soil types. In the future, these systems could be personalized to individual farmers based on their specific needs, goals, and constraints.

Integration with IoT: The Internet of Things (IoT) is a network of devices that consists of sensors and actuators which are connected to the internet and can exchange data with each other. Fertilizer recommendation systems could be integrated with

Use of Artificial Intelligence: Artificial Intelligence and technologies such as machine learning and deep learning are very useful to significantly improve the accuracy and efficiency of fertilizer recommendation systems. These technologies can be used to analyze large datasets and identify complex patterns and relationships between soil, crop, and fertilizer variables.

Sustainability: With growing concerns about the environmental impact of agriculture, there is a need for fertilizer recommendation systems that prioritize sustainability. Future systems could take into account factors such as carbon footprint, water usage, and biodiversity to provide recommendations that are not only profitable but also environmentally friendly.

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