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STUDY AND ANALYSIS ON MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE FOR SMART AGRICULTURE

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ABSTRACT

The goal of this research was to make an assessment of where AI and ML have been applied so far in agriculture and to make some educated speculations about where the field might go from here. This research takes a systematic literature review approach to the articles already published across a variety of scientific platforms that explore the overlap between artificial intelligence (AI) and supply chain management (SC) and machine learning (ML) in the food industry (FT). In this work, we propose a strategy for decreasing agricultural risks and bolstering smart farming practises. The wireless AI-based sensor will raise the bar for intelligent agriculture, which has seen progress in the past. In order to improve prediction in its current form, this research uses image-processing based machine learning techniques. Detecting and controlling cotton leaf diseases is the main objective of this study. The study covers a wide range of topics, including the detection of diseases on leaves, a server-based remote monitoring system, moisture and temperature sensing, and soil sensing. Plant illnesses caused by insects and other pathogens can drastically cut harvest yields if not treated promptly. In this study, we describe a system for assessing soil quality and warding against diseases that affect cotton leaves. Artificial intelligence's regression technique is used by the proposed system to detect and categorise leaf rots. After the virus is detected, the data will be sent to the farmers via an Android app.

1. INTRODUCITON

The global population is projected to reach 9–10 billion by 2050 [1, 2], calling for a corresponding rise in food production of 60–110 percent by the same year. Therefore, the future of farming is crucial to ending world hunger and maintaining a healthy diet for a growing population. Food safety scandals and mishaps, such as bovine spongiform encephalopathy and dioxin in chicken [3], have further emphasised the importance of a documented traceability system for quality control in the food chain. There will be considerable challenges in the coming years due to water scarcity and the resulting need for sustainable water management. For this reason, it is crucial to quickly implement a paradigm shift from a focus on increasing agricultural productivity to one that emphasises agricultural sustainability. The use of digital technologies like the Internet of Things (IoT), Artificial Intelligence (AI), and cloud computing can help encourage farmers and other stakeholders to adopt sustainable agriculture practices, which is crucial for ensuring the timely arrival of effective answers. Also, several applications of AI's specialised branches make use of geospatial intelligence software (particularly machine and deep learning algorithms). Our primary goal in conducting this review was to identify the most significant applications of AI and ML in the agricultural and food sectors.

1.1 The background

By 2050, the global human population is projected to reach 10 billion, making us the most numerous and, therefore, the most dominant species on Earth. However, as Earth's surface area will not expand to accommodate the growing number of humans, the demand for agricultural land and other essential resources will increase dramatically. The problem is exacerbated by other factors such as deforestation, climate change, water scarcity, and soil erosion.

Thankfully, today's technological developments are making life easier for people in many ways. The agriculture industry is undergoing a dramatic change due to the introduction of intelligent robots and smart technologies. Powered by Deep Learning, AI algorithms, Data Analytics, and Machine Learning systems, these solutions are perfect for tackling a wide variety of agricultural difficulties. They are contributing to the betterment of people's lives.

1.2 How Machine learning is paving way to precision agriculture?

More people are hungry, which means better crop production is more crucial than ever. Fortunately, the sector has access to cutting-edge tools that, thanks to machine learning capabilities, allow them to rise to the occasion.

- **Automatic detection of ripened crops and drought patterns**

Farms are becoming smart farms through the use of AI and ML, a practise known as precision agriculture. With the help of Big Data, AI, IoT, Machine Learning, the Cloud, and their respective applications, people are now able to automatically predict drought trends and track ripening patterns of crops. The introduction of smart tractors has also made it easier to harvest diseased or otherwise damaged crops.

The technique has a wide range of potential uses, including security, research analysis, terrain scanning, soil moisture monitoring, geographical analysis, and the identification of yield challenges in agriculture. Using machine learning and artificial intelligence, smart drones can pinpoint infected crops and spray pesticides with extreme precision in agricultural settings. They are also useful for amending the soil with macro and micronutrients and conducting tests to determine the soil's chemical composition, moisture level, pH, and other physical characteristics. Individuals can use the matching case to learn more about the disease that has halted the plant's growth and then compare that information with the diseases that are already catalogued in the application's AI-powered database.

When farmers have accurate, up-to-the-moment information on the spread of a disease, they may take preventative steps as soon as possible, reducing or even eliminating the risk of financial loss. With the use of data analytics, AI, and ML, the potential of Precision Agriculture is boundless. Afterwards, the data is quantified, analysed, and communicated to the farmers.

2. LITERATURE REVIEW

Artificial intelligence (AI) is a form of meta-creativity that seeks to mimic human intelligence and ability in technological systems, most notably computers, robots, and electronic devices [4]. Natural language processing (NLP) uses AI to understand human speech in real time, computer vision uses AI to see analog-to-digital conversions like videos, and speech recognition and expert systems use AI to model human judgement. Learning (gather data and generate algorithms to convert it into usable information), reasoning (select the appropriate algorithm to achieve a desired result), and self-correction (constantly modify designed algorithms to ensure they provide the most accurate results) are the three underlying cognitive abilities that form the basis of AI encoding [5].

AI is being used in a growing number of fields, including finance, healthcare, retail, pharmaceutical research, intelligent process automation, and marketing. One of the main areas of research in artificial intelligence (AI) is machine learning (ML), which helps people be more efficient and innovative at work. Machine learning (ML) use statistical and mathematical techniques to sift through datasets in search of patterns in order to generate predictions and take actions based on the data. There are a number of ways to accomplish this. Symbolic approaches (in which the generated rules and instances are represented explicitly) and subsymbolic approaches (in which they are not) allow for a broad categorization (artificial neuronal networks: ANN). There are three main types of ML methods: supervised learning, unsupervised learning, and reinforcement learning. The goal of this method, as defined by supervised learning, is to establish a connection between the input variables and the desired output variable [6].

We use the labelled data in conjunction with our prior knowledge of the inputs and outcomes to create the prediction model. Supervised learning encompasses a wide variety of methods, such as decision trees, Bayesian networks, and regression analysis. With unlabeled datasets, algorithms like artificial neural networks, clustering, genetic algorithms, and deep learning are used to make predictions about the dataset variables. According to Jordan and Mitchell [7], two of the most prominent uses of this unsupervised machine learning approach are dimensionality reduction and exploratory data analysis.

The third category of ML tasks is known as reinforcement learning, and it encompasses a wide variety of algorithms used for machine skill acquisition, robot navigation, and real-time decision making. This ML project uses the learner's actions in the environment as both training and testing. There is a tension between exploring and taking advantage of one's environment because the learner receives reinforcement for his interactions with the environment. Instead of relying on previously acquired knowledge, learners should try out novel situations where they can gather more information [8].

Now more than ever, artificial intelligence has the potential to revolutionise the agricultural and food processing sectors. In fact, AI-based approaches contribute significantly and aid in comprehending a model's identification, service creation, and the decision-making processes in support of the numerous stages of the supply chain for agri-food applications. Understanding issues in agriculture can be addressed with the help of AI tools, which propose algorithms for performance evaluation, pattern classification, and problem/phenomenon prediction. This can be used for things like pest identification and management, irrigation system administration, and so on. Artificial intelligence (AI) is being used increasingly in the agricultural sector to make more resource-efficient and precise judgments, hence increasing productivity [4]. The purpose of this is to develop algorithms for assessing performance, categorising patterns, and foreseeing unforeseen problems or phenomena by means of artificial intelligence tools. Researches are analysing biotic and abiotic factors via remote sensing and sensors to enhance agriculture and livestock management [4, 9].

The agri-food industry and related industries stand to benefit greatly from AI's widespread adoption and deployment. To begin, AI helps farmers improve their yields, harvests, and overall bottom line. The possibility for healthy crop production is increased, and checks for damaged crops are emphasised more heavily. In addition, AI is already being put to use in applications such as automated machine modifications for things like 98% accurate disease or pest identification and weather forecasting. To that end, recent work by Sujatha et al. [10] compared the efficacy of machine learning (ML) and deep learning (DL) methods for spotting and naming citrus plant leaf disease. It was shown that, when testing the ability to categorise diseases, the VGG-16 deep learning algorithm yielded the best accurate results. Second, advancements in AI have helped agro-based firms improve efficiency by allowing for better crop management. Because of this, a growing number of tech firms are funding the development of algorithms with practical applications in farming. These algorithms are useful for farmers because they assist them combat issues like climate change and pest and weed infestations.

By analysing data on corn yield in the Midwest of the United States, Crane-Droesch [11] developed a novel modelling approach for augmenting parametric statistical models with deep neural networks, which we term semiparametric neural networks (SNNs), and demonstrated its superiority over conventional statistical methods and fully nonparametric neural networks in predicting yields for years not used in model training. Finally, the use of AI tools could assist farmers in staying abreast of the latest weather predicting information, allowing them to boost yields and profitability without putting their crop at risk. Last but not least, AI helps farmers gain insight and knowledge, and finally, take preventative action by putting into place processes, so that they can analyse the collected data and make an informed decision at the right moment.

In reality, Fente and Singh [12] used a recurrent neural network (RNN) with the long-short-term memory (LSTM) technique to implement a weather forecasting model, gathering a wide range of weather parameters (temperature, precipitation, wind speed, pressure, dew point visibility, and humidity) from the Indian climate data centre. They found that the technique they used produced very accurate results compared to other techniques of weather forecasting. Using a camera recognition tool or a deep learning based tool to examine flora patterns in farms and to simultaneously comprehend soil faults, plant pests, and illnesses, AI approaches can keep an eye on soil health and management.

In fact, Suchithra and Pai [13] used the Extreme Learning Machine (ELM) technique with different activation functions like hard limit, sine-squared, triangular basis, hyperbolic tangent, and gaussian radial basis to classify and predict the soil fertility indices and pH levels of the Kerala north central laterite Indian region. It was demonstrated that in four out of five examples, the best results were obtained by first using the Gaussian radical basis function, and then by using the hyperbolic tangent. On the other hand, when it came to the pH classification task, the hyperbolic tangent produced the best performance (90%) whereas the gaussian radial basis provided only moderate scores (65%). Fifthly, reducing the need for pesticides is a major functional benefit of using AI technology. For instance, using AI tools such as robots, computer vision, and machine learning can assist farmers in spraying herbicides only where the weeds are, reducing the need to blanket a field in a toxic fog. As a result, farmers are receiving assistance from artificial intelligence systems to devise better methods of weed control. Finally, there are additional benefits to implementing AI-based technologies in the agri-food supply chain, including but not limited to: lowering the cost of training employees, shortening the time it takes to solve problems, decreasing the number of mistakes made by humans, decreasing the need for human intervention, and providing an automated good, accurate, and robust decision-making at the right time and at a low cost [14].

3. REAL-TIME SOLUTIONS FOR AGRICULTURAL ISSUES THROUGH CHATBOTS

Chatbots are conversational virtual assistants that use artificial intelligence to carry out scripted dialogues with their human users. Machine learning techniques are used in their creation, allowing users to decode the chatter of others and craft conversations tailored to each individual.

Among the many possible applications for chatbots, media, agriculture, retail, and transportation are among the frontrunners. This tool not only aids the farmers, but also allows them to get instantaneous responses to any queries or problems they may have.

Currently, we are making strides toward a precision agriculture supported by artificial intelligence, in which machines perform all necessary agricultural tasks. The farmers have fought a long and uphill battle against numerous internal and external factors, such as pests, extreme weather, a lack of water, and so on.

Using techniques such as Big Data and AI Analytics, it is now possible to buck the trend. It contributes to the optimization of the entire farmland while simultaneously guaranteeing that every area of it is utilised effectively.

Additionally, the cutting-edge technology examines each plant in order to monitor its development and state of health. Any problems that may be caused by pests are found and reported to the affected individuals as soon as possible. Using the traditional approaches to agriculture made this impossible to achieve.

3.1 ML powered technologies optimize the entire farming process

Big Data Analytics, AI and ML, and smart edge devices like drones, GPS, and sensors are very useful in smart greenhouses, fish farming, and animal monitoring.

The revolutionary nature of this shift in agriculture is heightened by the use of cutting-edge Blockchain technology. Transparency, efficiency, and accountability are all maintained and improved as a result. In addition to improving farming in general, this innovation helps streamline the supply chain.

3.2 Maximized yield of crops

Superior plant performance begins with high-quality seeds and a wide range of options. Tools powered by machine learning facilitate optimal conditions for rapid and healthy crop development. And the selection of hybrid seeds is crucial to the yield of the crop. The seed must be suitable for the farmers' purposes.

With the help of AI and ML, farmers may learn how various seed varieties fare in a variety of climates and soil types. As a result, farmers are able to make well-informed decisions in a timely manner, thereby reducing the likelihood of crop failure from disease or other causes.

That means AI is not only affecting the digital economy, but also the agricultural sector.

Farmers are now better equipped to adapt to shifting consumer preferences, market conditions, and annual yields thanks to technological advancements. Farmers can increase their profit from their produce by using this method. So, farmers may maximise their area and boost their yield by a factor of 6 or 7 per acre.

3.3 The Future of Agriculture will be Technology-Empowered

As a result of how far along the AI development path we've come, today's tractor equipment can effectively remove diseased or ruined plants from a crop. Satellite imaging also provides visuals of various drought patterns.

To further aid with diagnosis, there are now apps driven by AI and ML that farmers may use. The purpose of these apps is to provide farmers with comprehensive data about plants. To boot, it aids in the discovery of solutions to the problem at hand.

However, the potential of this new technology cannot be fully realised without constant work from innovators in agriculture, technology, and thought leadership. Furthermore, governments have a responsibility to advocate for Precision Agriculture and promote its benefits.

New technologies, such as Machine learning and Artificial Intelligence, have the potential to greatly improve farmers' output and productivity, and as such, farmers should be encouraged and trained to adopt these new tools.

4. MATERIALS AND METHODS

4.1. Use of WSN in Agriculture

Wireless sensor networks allow for the collection of climate, hydrographic, pressure, movement, soil, plant, and pest data on a spatial and temporal scale, as well as the reporting of best practises to the farmer. Having access to this kind of information regularly would be a huge help for him. When farmers are faced with unfavourable conditions, they can employ automatic control systems to regulate irrigation, fertilisation, and insect management. Irrigation upkeep is an essential part of precision farming.

Precision farming (PA) requires adaptability because numerous factors, such as soil type and temperature, vary greatly from location to location. Costly irrigation controls are often necessary to manage limited water supplies. Ineffectiveness epitomises their operation. WSNs also have some room for development; for example, they can be imprecise, fragile, power-hungry, and prone to losing contact in adverse environments, especially in agriculture. Cultivation field surveillance plays an essential role in maximising agricultural efficiency by minimising resource waste and maximising yields from activities like irrigation and fertilisation because farmers have access to and can make decisions based on reliable data regarding climate factors, soil conditions, and plant statuses and changes. Even though agricultural field monitoring typically involves humans, one-off agro weather stations, and wired sensor network systems, high density and flexible deployment of instruments for gathering data in real time is important for this issue, which is intricately intertwined with precise farming. With the goal of providing low-cost, flexible, user-friendly, and high-precision benefits, WSNs have been developed for real-time agricultural monitoring. We focus on the ways in which WSNs can be applied in the agricultural and farming sectors.

4.1.1. Irrigation Management System

A more efficient irrigation system is needed to increase agricultural output while minimising water waste. The alarming drop in groundwater levels is another reason a new system is needed. The micro-irrigation technique used here is both economical and efficient in terms of water usage. Microirrigation efficiency can be improved with the right understanding of the environment and the soil. WSNs serve as the organising mechanism for this.

4.1.2. Farming System Monitoring

Modern farming makes use of a number of different pieces of cutting-edge technology and machinery. The new method of using this equipment simplifies operations generally and permits famine automation. With the use of remote monitoring tools, large-scale farms can be managed more effectively. The effectiveness of the system can be enhanced with the addition of other information like satellite images and weather forecasts.

4.1.3. Pest and Disease Control

The controlled use of pesticides and fertilisers aids in increasing crop quality while decreasing agricultural costs. However, the likelihood and presence of pests in crops must be monitored to regulate pesticide use. We need data about the surrounding environment, like the temperature, humidity, and wind speed, to accomplish this. These events can be tracked and predicted in a specific area by a WSN working on its own.

4.1.4. Controlled Use of Fertilizers

Application of fertiliser is crucial to plant growth and quality. However, maximising fertiliser use in productive areas is labor-intensive. Fertilizers for agriculture allow for the tracking of nutrient levels in the soil, including nitrogen (N), phosphorus (P), potassium (K), and pH. This means that the crop's quality and the nutritional stability of the soil can be maintained.

4.1.5. Groundwater Quality Monitoring

Groundwater quality is declining because of the increased use of fertilisers and pesticides. Wireless technology improves the effectiveness of sensor nodes placed in water to regulate water quality.

4.1.6. Remote Control and Diagnosis

A wide variety of farm devices, including pumps, lights, heaters, and machine valves, may be managed and diagnosed from a distance due to IoT connectivity.

4.2 Data Acquisition

The data acquisition phase involves the placement of the data acquisition device at multiple sensor nodes. The data collection module in agricultural production collects information in real time from processing variables (temperature, light intensity, humidity, nutritional product solution level, atomization quantities, and photos of plants and sick plants). Last but not least, the control and management subsystem functions as the brains of the operation (CPU). Raspberry Pi and WRTnod, two components of the central processing unit, are built for storing, managing, and transmitting data acquired from nodes to the webserver in real time, among other crucial functions. Farmers can now keep an eye on their farms from afar using a smartphone app and this cutting-edge technology.

4.3. Image Preprocessing

The goal of image preprocessing is to remove unwanted elements from an image, such as noise or foreground objects. This process takes more time because the original image's pixel size is high. Miniaturizing an image reduces the time it takes to process it and the size of each individual pixel.

4.4. Image Segmentation

Segmenting images is a typical technique for identifying individual pixels in an image for a specific purpose. It separates an image into distinct regions that share a high degree of pixel similarity.

4.5. Feature Extraction

Disease detection relies heavily on feature extraction. It serves a crucial role in determining what something is. Numerous image processing uses cases involve feature extraction. Color, texture edges, and morphology are all used as features in sickness detection.

4.6. Classification

The categorization system is used to determine the specific leaf disease at this, the final stage of the disease identification process. Several forms of AI are put to use in the search for leaf diseases.

4.6.1. Random Forest

Bagging is an innovative technique for random tree planting. By averaging predictions by sampling and substitution, "bagging" intended to reduce prediction variation. Random forests add a new variable to the packing process by picking and creating a tree at random, with characteristic changes and frequent repetitions; this process finally makes all forecasts measurable. Thus, in terms of bias and variance, the random forest is capable and effective.

5. RESULTS AND STUDY

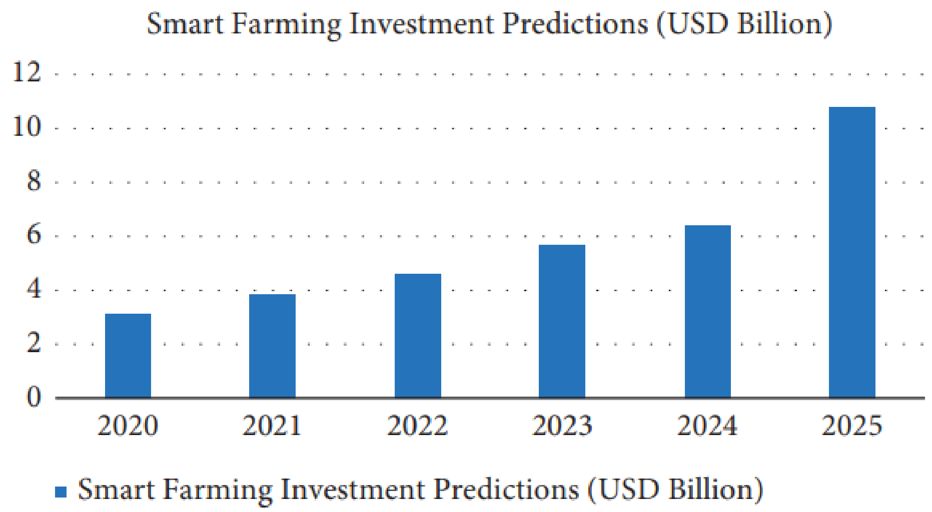

Figure 1: Prediction of smart farming investments.

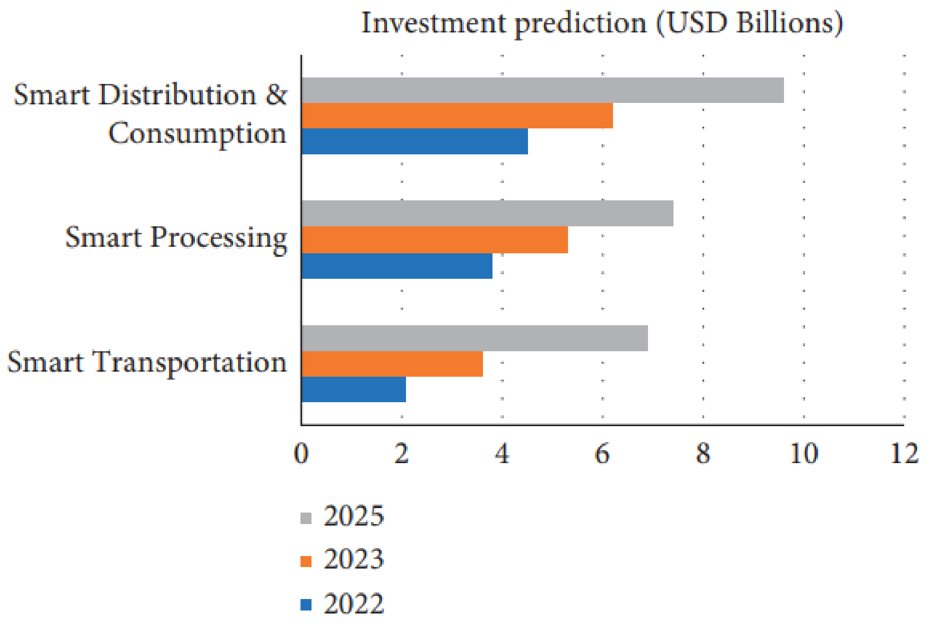

Figure 2: Future investment prediction in FI.

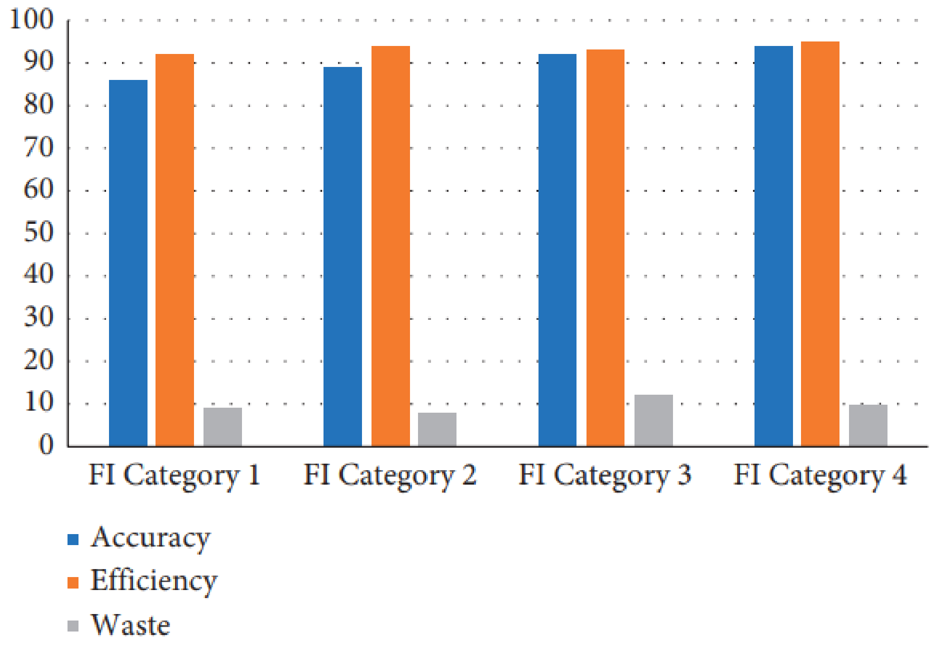

Figure 3: AI and ML category-wise possibilities for enhancing the FI.

Analysis of the data shows a steadily expanding market for smart farming solutions. Moneyed people are spending big to improve agricultural output. The expected expansion of intelligent farming over the next few years is seen in Figure 1. Figure 2 depicts investments in the remaining three categories.

If FIs are sorted into predetermined categories and attention is narrowed to a single person via an AI/ML-powered system, productivity will soar. Figure 3 demonstrates how the four types of FI can improve in precision, efficiency, and waste reduction with the help of AI and ML applications.

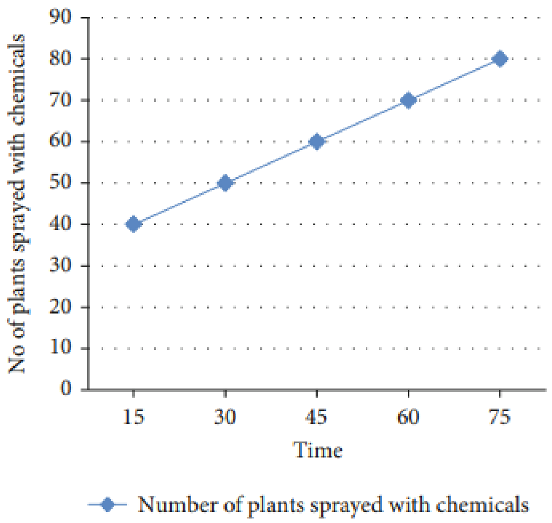

Figure 4: Analysis of time and chemicals requirements according to the number of plants.

Approximately 33.36 minutes were required for a maximum of 75 plants, each of which measured 20 centimetres in length. According to Figure 4, this will require 30 mL of chemicals.

CONCLUSION

Precision farming provided by ML also helps farmers deal with the real-world challenges they confront by providing them with data-driven, AI-based decision making. In the realm of agriculture, ML's applications are limitless. This means the apps need to be solid and dependable. Extremely powerful ML tools can adapt to shifting environmental conditions. Additionally, it aids people in making decisions in the moment and provides a suitable framework for gathering contextual information. In agriculture, like in many other fields, the value of AI is widely acknowledged. There is a growing realisation that a specific subset of agricultural technologies is essential to the continued success of businesses in the field. Farms are a major source of data due to the sheer volume of information gathered. Infrastructures based on wireless communication, the Internet of Things, robotics, and artificial intelligence are in use. The algorithms of artificial intelligence make it possible to glean useful information from the deluge of data. According to the discussion, the primary goal of this endeavour is to identify and track cotton leaf diseases. The second aim is to keep an eye on agricultural indicators. There is a significant correlation between a farmer's success and his or her ability to accurately identify and diagnose plant diseases using AI. This research examines the use of AI to identify a diseased leaf on a plant. Eliminating parts of the affected sheet could help in accurately identifying and categorising various plant diseases. This system may automatically spray pesticides on sick plants, transmit updates to the user, and detect and report on plant diseases. The SVM algorithm improves farmers' harvests by 98.34%, proving its efficacy in disease identification and management through the detection of bacterial blight. A future update will incorporate the Convolutional Neural Network model for disease classification, which builds on the current work described here.

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