CARPATHIAN JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

journal homepage: **http://chimie-biologie.ubm.ro/carpathian_journal/index.html**

ARTIFICIAL INTELLIGENCE AND BIG DATA ANALYTICS-BASED OPTIMIZATION OF CROP YIELDS IN SUSTAINABLE AGRICULTURE

S. Rama Krishna[1]✉, Ravi Kumar[2], J. Dafni Rose[3], Vinod Patidar[4], Anita Soni[5], Dhaval Mehta[6], Amol Ranadive[7]

[1] Department of Computer Science & Engineering, GSoT, GITAM (Deemed-to-be-University) Hyderabad- 502329
[2] Department of Electronics and Communication Engineering, Jaypee University of Engineering and Technology, Guna
[3]Department of Computer science and Engineering, St.Joseph's Institute of Technology, Chennai-119, India
[4] Department of Computer Science and Engineering, Parul Institute of Techmology (PIT), Parul University, Vadodara Gujarat.
[5] Professor CSE, IES University, Bhopal
[6] School of Engineering & Technology, Navrachana University
[7] School of Business & Law, Navrachana University
✉rsankara@gitam.edu

https://doi.org/10.34302/SI/238

Article history:
Received
04 July /2023
Accepted
04 October 2023

Keywords:
Artificial Intelligence;
Fertilizers;
Farmers;
Environment;
Farming;
Soil.

ABSTRACT

Rural residents are gradually beginning to agree with their urban counterparts. Site-specific tweaking of administration requires precision farming since it accounts for soil nutrients that are specific to the needs of each crop. Careful planning is necessary to optimize yields, but a precise evaluation of the soil's capabilities and constraints is also crucial, as it will form the basis for choosing the right manure, application quantity, and timing. Farmers' Preparation times are notoriously hard to estimate, so you'll need to depend on gut feelings, trial and error, a healthy dose of mystery, and critical thinking. Inefficient outcomes, wasted resources, and exacerbated environmental harm are only some of the numerous negative consequences of these issues. Because of a lack of information, farmers often have no idea how their decisions will influence their crop yields or the state of the environment. Based on the results of this research, it seems that adapting manure management strategies to the specific needs of certain crops and regions might help mitigate the negative effects of excess fertilizer and manure on the environment. By using artificial intelligence and big data analytics, the agri-food industry has the potential to make significant contributions toward meeting the growing food demand throughout the world and attaining sustainability in spite of the many challenges it faces. Soil samples might be sent to universities for analysis; however, this method is ill-considered, time-consuming, and unreliable. Recommendations such as predicted compost, NPK supplementation, and application time may be generated using weather prediction and an ANN's development.

1. Introduction

Both organic manure and synthetic fertilizers may have positive and negative effects on plant development and soil fertility. Chemical fertilizers are cheap and easy for plants to absorb since they contain a high concentration of nutrients. (IoT) Consumers needed a profound impression of agriculture ever since it was first introduced (Alreshidi, 2019). The agricultural business has undergone a fourth revolution in recent years, dubbed Agricultural 4.0, as a consequence of the incorporation of info and communication tools (ICT) hooked on modern agricultural operations. Possible agricultural technologies include the custom of unmanned aerial automobiles, remote distinguishing data, the Internet of Things (IoT), big data analytics (BDA), and machine learning (ML). The usage of AI and big data analytics has been trending upward in the farming sector lately, and this might dramatically alter the way crops are managed. Despite the many advantages of new technologies, it is crucial to evaluate the associated ethical concerns and hazards. It is morally important to ensure data privacy and security because of the potential for the disclosure of farmers' personal information resulting from the collection and analysis of massive amounts of agricultural data.

However, using too much fertilizer may lead to problems including nutrient loss, water pollution (both surface and ground), soil acidification or basification, the death of beneficial microbes, and an increase in insect infestations. When compared to synthetic fertilizers, the benefits of organic manure pale in comparison (Delgado et al., 2019). Low nutrient density, slower decomposition, and varying nutrient content depending on the organic source are all disadvantages. Ecological circumstances, development state, dirt position, irrigation aquatic, bother and compost treatments, wildflower management, then conservatory manufacture settings remain only approximately of the agricultural features that may be monitored with the use of smart farming. This helps farmers maximize output from their crops while minimizing expenses and making the most of available resources (Misra et al., 2022). Organic manure is widely used in agriculture because of its many benefits, including: increasing soil nutrition through microbial activity; balancing soil nutrition; assisting in the decomposition of damaging physical hip the dirt; improving the dirt's internal construction; facilitating the growth of roots; and increasing the soil's capacity to hold water (Sharma et al., 2020). These and other benefits have led to the widespread use of organic manure in the agricultural sector. "Smart farming solutions based on the Internet of Things (IoT)" refers to a system that uses devices (bright, wetness, warmth, dampness gratified, crop development, etc.) to monitor a farming arena and automate the irrigation system. The Internet of Things (IoT) provides access to these options.

Advanced tools in the fields of artificial intelligence and big data analytics have made it possible for environmentally friendly farmers to increase their harvests while minimizing their effects on the natural environment. These technologies provide unparalleled insights into agricultural growth patterns, soil health, weather patterns, and pest control by harnessing the power of complex algorithms and vast data processing. This optimization not only boosts productivity, but also encourages more sustainable practices by decreasing resource waste, decreasing resource impact on the environment, and raising resource use efficiency. Farmers may be able to improve yields and create a more sustainable agricultural system by adopting AI and big data analytics, which enables data-driven choices, precision farming methods, and individualized approaches to crop management.

The Internet is one of the most advanced kinds of wireless communication technologies, allowing farmers to monitor their crops from almost anywhere. The key idea is that a lot of separate groups talk to one another. Real-world things and objects can only access the internet if they use certain addressing schemes (Eli-Chukwu, 2019). Many different types of businesses might benefit from using Internet of Things (IoT) technology. Many various sectors, such as manufacturing, shipping, healthcare, automotive, and (IoT), are potential outlets for agricultural products. The dirt's fruitfulness is only unique of several features that influence the amount of food produced. Soil fertility affects the amount of nutrients in the soil and the crop's ability to remain healthy over time (Javaid et al., 2023). Climate remains a major consideration cutting-edge determining the best time to apply since precipitation and sunshine levels may affect how nutrients are distributed in the soil. More and more farms are switching to organic fertilizers. Because they replenish the earth's nutrients as they nourish growing plants, organic fertilizers last far longer than their synthetic counterparts. Organic fertilizers provide the proper nutrients for the soil's microbial populations and the earthworms that inhabit it (Holzinger et al., 2023).

There are several ways in which artificial intelligence and big data analytics are assisting today's farmers. One such approach is by allowing them to do more with fewer resources. Data on soil conditions, weather patterns, and crop growth are analyzed to determine the most efficient use of available agricultural resources. Smart irrigation systems are the most water-efficient because they monitor soil health and plant requirements. Artificial intelligence's (AI) enhanced detection and prediction skills aid in better disease and pest management, which in turn allows for more precise drug dosing. The method of yield optimization may lead to increased output by collecting information on variables like crop density and fertilizer management. By anticipating customer demand and looking for the most efficient methods to carry and distribute goods, supply chain optimization helps cut down on waste. In general, farmers are able to make more environmentally responsible choices with the help of AI and big data, which in turn leads to less waste.

It has only been within the past few years that we have seen the so-called "green revolution" for organized development along with broad adoption of constructed fertilizers and pesticides, rotations of crops, other advancements in cultivating execution, and the domestication of non-vegetable animals. These changes are just the tip of the iceberg of agricultural revolutions. We believe that the increasing use of ICT in agricultural contexts represents the beginning of a fourth revolution in fashionable crop growing (Streich et al., 2020). To aid farmers in better grasping their farms' needs, several strategies have been developed and used. Some people, in addition to trying home remedies, use the diagnostic services provided by agricultural labs, mobile labs, and smart systems. All of them have their individual customary of glitches that brand them rough towards custom on a farm. The area of this investigation is to create a perfect that can evaluate NPK ranks depending on environmental conditions like pH, temperature and then provide enricher and application timing recommendations to farmers (Zhang et al., 2021). This is done to avoid fertilizer damage from things like sun and rain, which may cause burn, leaching, wash-off, gentrification, and volatilization. Smart agricultural methods may allow for far more precision when planting and harvesting. By reducing the number of passes needed to complete a task, the distance a tractor must travel is cut in half when overlaps are removed.

Uneven patches of scorched plants and stunted, underperforming plants result from using too much or too little spray, lowering crop quality (Linaza et al., 2021). Farmers that employ section control have a better chance of consistently growing healthy, uniform crops by reducing the amount of overlap between rows. However, Internet access is crucial for precision farming and other forms of smart agriculture. Most rural areas in underdeveloped countries do not meet this criteria. It doesn't help that the Internet speed is reduced. Farmers may be able to improve their bottom lines by taking a more strategic approach to their labor. As the quality of spatially explicit data increases, farmers may reduce the amount of resources they invest in their operations, saving both time and money (Andronie et al., 2021). Accurate, customized weather predictions, yield estimates, and likelihood maps for different illnesses and natural catastrophes will be created from a complete net of atmospheric and climatic info, allowing for optimal crop production. New opportunities for security and economic growth are opened up by site-specific data for all participants in the retailers in equally emerging and settled economies. This is due to the fact that the information gathered at each site is unique. The agricultural sector will need to protect the environment while also providing for a rapidly expanding world population. The rising global population will cause this problem by increasing demand on the world's food supply. This means that we need cutting-edge agroecosystem technology for the biosphere's growing population while reducing the ecological destruction caused by conventional agricultural practices like chemical fertilization and improper waste management (Saiz-Rubio & Rovira-Más, 2020). This research describes a ground-breaking method for establishing the optimal composition of manure for soil, which boosts yields without negatively impacting the environment.

1.1 Literature Review:

For centuries, farmers have turned to natural manure composed of animal waste to offset the environmental damage and decreased crop yields associated with chemical fertilizers. Animal waste is used to make natural manure (Kakani et al., 2020). Many positive outcomes result from recycling manure, including better soil quality and higher agricultural yields, the preservation of natural ecosystems, and lower expenses associated with treating sewage and water. Manure recycling is an additional means through which natural ecosystems are protected. However, it is uncertain whether benefits are achieved by combining organic manure with chemical fertilizer. This is because it is unclear what advantages are realized. This sensor data, when processed by edge computing and analytics as part of the Internet of Things, can provide farmers with invaluable insights into things like the state of the weather, the health of crops, the likelihood of harvests, and the presence of animal and plant diseases (Sánchez et al., 2020). When nitrogen, phosphate, and potassium chemical fertilizer and animal organic manure are applied together to a soil, the growth rates of mint (Mentha arvensis) and mustard (Brassica juncea) are maintained at much higher levels. Soils enriched with nitrogen, phosphate, and potassium support substantially greater growth rates for mint (Mentha arvensis) and mustard (Brassica juncea). Soil levels of nitrogen are higher, phosphorus is higher, and potassium is higher, demonstrating this. Sorghum (Pennisetum glaucum) was grown on farms using either just chemical fertilizers or a combination of chemical and organic manure, as described.

The purpose of this analysis was to identify which approach was more productive. Soil organic carbon, nitrogen, phosphate, and potassium all increased when chemical fertilizers were used in combination with organic manure, proving organic manure's worth in tropical farming (Ganeshkumar et al., 2021). Tasks like analyzing large data sets, identifying patterns, and developing better farming techniques all benefit greatly from the use of artificial intelligence. Large quantities of agricultural data, such as crop yields, weather patterns, soil conditions, and insect infestation information, may be evaluated by artificial intelligence (AI) thanks to the use of complicated algorithms and machine learning methods. To help farmers make data-driven choices and implement precision farming approaches, AI systems may reveal previously unseen correlations and patterns within these datasets. Analytics-driven by AI might help farmers make better decisions about when to plant and harvest, how to distribute resources, how to detect diseases, and how to manage their crops. Some examples of possible analysis are shown above. In the end, AI equips farmers with the resources they need to improve operations in terms of efficiency, production, waste reduction, and the creation of environmentally friendly farming practices. When compared to the amount of research done in the forestry industry, the number of agricultural studies has been relatively small. According to a recent study, the soil of a grove in the Northern US was found to have high levels of potassium, phosphate, and magnesium. Both organic bovine dung and a slow-release artificial fertilizer were used in the experiment. However, found that chemical composts permit much greater growth and root advancement than the use of cow natural fertilizer in a poplar forest with clay soil (Guo & Wang, 2019). This was uncovered in the wooded area, namely in a poplar grove. Preparation in this regard comprises distributing soil supplements in a simple manner, which is essential for maintaining consistent tall biomass efficiency via the use of soil supplements (Nasirahmadi & Hensel, 2022). The results provided showed that 20–30% of the total amount spent on biomass production was attributable to fertilization expenditures. However, the properties of the natural excrement and the different types of manure largely influence the effects of mixing chemical compost with natural feces on the growth of trees and the density of the soil. The nitrogen content of the natural fertilizer is a major factor in determining how much should be applied (Harfouche et al., 2019). However, further care is required in this case since the ratios of the various supplements, other than nitrogen, might change depending on the requirements of the trees. Even though most agricultural work is done informally and inefficiently, the IT industry recognizes its latent potential and is working to formalize the sector via the use of information and communications technologies (Khan et al., 2021). Most agricultural work is done inefficiently and in an unofficial capacity, but the IT industry sees huge potential in the agricultural sector. By gleaning insights from data and disseminating them to farmers, we can help them improve their agricultural practices and tap into their latent output.

One way to ensure higher output is to remove the barriers that prevent better production, such as the difficulties farmers face in obtaining reliable soil testing results, climate estimates, and additional information which will assist them create more informed choices (Talaviya et al., 2020). The term "precision farming" is used to describe a specific technique for increasing crop yields through the strategic application of cutting-edge technologies like sensor technologies, GPS, and big data optimization. This can be accomplished while maintaining or even improving crop quality and reducing costs. What we now call "precision farming" is a technique that employs cutting-edge tools like sensor networks, GPS systems, and big data optimization to maximize crop production (Alibabaei et al., 2021). They provide for a more in-depth comprehension of a situation on the ground, leading to improved arrangement decisions that boost output and minimize waste. These tools facilitate the gathering and analysis of data, which in turn enables the presentation of information in a manner that is more likely to elicit the desired reactions. With the use of sensors, "smart farming" may be implemented in agricultural settings.

2. Materials and Methods:

This section explains how artificial intelligence was used for the task of selecting and composing dung. As an artificial intelligence (AI) method, ANN is utilized to provide the greatest potential assistance to farmers. The framework was developed using the subsequent steps. This section goes into depth.

In recent years, it has become more vital to improve agricultural output using AI methods including Artificial Neural Networks (ANN), Decision Trees, Random Forest, Support Vector Machines (SVM), and Genetic approaches. These algorithms collect data from many different agricultural sources, analyze it, and then take the necessary steps depending on their findings. By considering inputs such as weather, insect prevalence, and soil health, both ANN and Decision Trees may improve crop management tactics. To improve its precision, Random Forest employs a forest of decision trees. SVMs are useful for disease classification, whereas GAs enhance crop breeding. Altogether, these AI algorithms help farmers raise more productive crops with less effort.

2.1. Materials Collection:

The vast majority of the material that went into the soil's information and production ratings came from a variety of surveys and websites that were sponsored by the government. These were distributed across the agricultural community using agricultural publications hip the procedure of workroom earth archives then information aimed at the nutrient organization. For the purpose of monitoring mud parameters such as pH, temperatures, and NPK levels, a database containing one thousand soil samples is used. Speaking with those who specialize in soil helped shed light on the problem and provided clarity about the parameters for soil studies, which have since been standardized.

Certain criteria for soil research were defined after conversations with various soil professionals. Three crucial factors are the environmental temperature, the NPK content (nutrient, phosphorus, and potassium levels), and the pH. When these criteria are established, researchers will be able to directly compare the outcomes of their soil studies. By first identifying, and then frequently analyzing, the important soil properties, farmers that practice sustainable agriculture may be able to maximize crop yields using AI and big data analytics.

2.1.2 Materials Processing:

The information was recorded in the crucial surpass expectations pages once it was collated from different pieces of paper, like the association logs. During the data cleaning process, we were able to identify which portions of the data required prioritization and eliminate any irrelevant data or materials. In particular, we were able to single out factors that had previously been overlooked for this effort and subsequently remove them. In order to prepare, test, and verify that the necessary permissions have been granted, the whole data collection is retained in its aggregate form. When it came to creating trustworthy models, this tactic was of the utmost importance.

Sustainable agriculture relies on the gathering and analysis of a large variety of data to maximize crop yield. In this section, you'll find data on a wide range of farming-related issues, such as crop yields and conditions, soil conditions, precipitation, pests and diseases, and farming operations. Artificial intelligence and big data analytics might be used to combine all of this data and draw conclusions about trends, crop performance, and management strategies. Farmers' productivity, crop yields, and commitment to environmentally responsible farming methods all benefit from this.

2.2 Methods:

2.2.1 Coaching for Roles:

During the learning process, both the information gathered from the inputs provided by the model and the projected results are employed. After that, the model may be used to produce forecasts. The artificially generated neural networks used in the machine learning approach were the key data structure for the whole operation. The data sets were split into two categories: preparation (79%), and testing (35%), to see whether it was feasible to assess precise compost measurements (yes or no). Soil temperature, soil pH, and NPK values were entered into a model to predict the recommended NPK soil levels as an output. All of the inputs led to this result.

2.2.2 Structured System:

In Figure 1, we see a detailed representation of the prototype. The data collected by the sensor is sent to the model. The most efficient kind of fertilizer is the one the software suggests using. Using a unified API for weather forecasts, it is feasible to determine whether or not fertilizer distribution at a certain time is absolutely necessary. The majority of the historical data utilized in the training of models comes from digital sources that are made available by the appropriate authorities, in addition to a wide range of surveys. Figure 1 depicts the block architecture used by the ANN-based intelligent manure composition. Various sensors will be used to determine the soil's physiochemical properties before the right mixture is applied.

2.2.3. Verification and certification of prototypes:

Prototypes are shown to be reliable representations of the final product after extensive research and testing. Artificial neural networks (ANN) were trained using data on what conditions promote plant growth, including the appropriate temperature, pH, and NPK sources. The intricate and nonlinear relationships between chemical concentrations in soil and pH values are studied and recreated using artificial neural network models. The utilization of training data allowed for this to be achieved. Sensors were placed above the crops to measure soil temperature and acidity, yielding results that are far more precise. The ANN classifier and preprocessing were part of the machine-learning model that also included the weather API data and the suggested amount of fertilizer. Farmers could rely on accurate data from the system because it is thoroughly tested to make sure it had everything it needed to function properly. This included clients, IoT devices, a weather API, a database, a server, and a machine-learning model.

After a lot of study, the best growing temperature, pH, and NPK sources were found. All of the tests used ANN because the inputs and results were unique. Artificial neural networks were able to learn and copy complex and nonlinear intelligence, such as the complex link between soil chemicals and PH at different temperatures, which helped find the best approach. Artificial neural networks, which are based on the structure of the human brain, could have the same complex and subtle intelligence as the human brain. Ann has all the skills she needs to do the job. It is especially good at keeping track of trends and connections, like the ones between the supply of supplements and the pH of the soil. Another goal is to make sure that links can be trusted. Both depend on the temperature. There are a lot of relationships, such as those between temperature, pH, nitrogen, phosphorus, and potassium. In the system architecture, the design, framework, and what users can expect are all laid out. Also, the system design shows how the different parts of the system work together. Figure 1 shows the illustrated manure proposal's subsystems and how they work with each other. The suggested design is made up of many different parts that all work together. These parts include clients, Internet of Things devices (such as temperature, PH, and Arduino sensors), a climate API, a database or server, and a machine learning model.

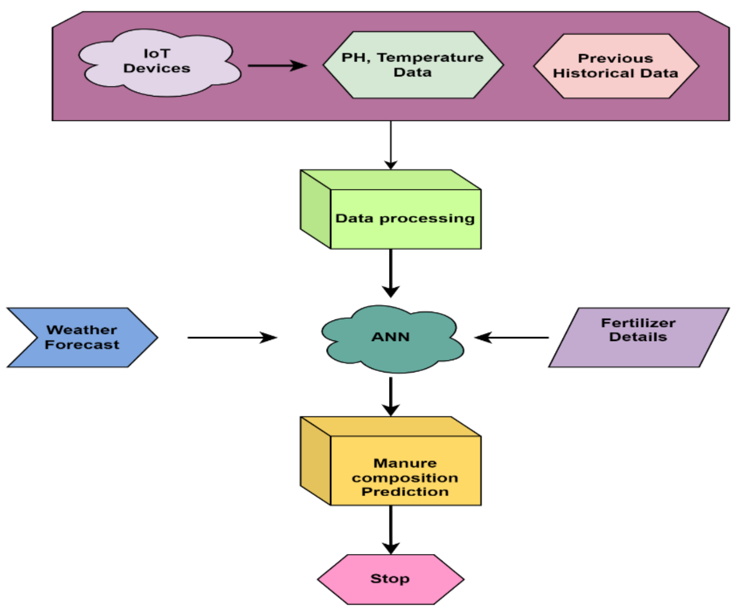

Figure 1. Formulation of intelligent fertilizer using an ANN concept.

The machine learning model is based on this underlying architecture. Above the crop, Internet of Things Hubs with soil temperature and acidity sensors are placed. As a result, we can gather more precise information. Then, the machine learning example makes use of the database containing these values. The machine learning part is made up of the artificial neural network (ANN) classifier and the preprocessing. The classifier is the part of the system that really decides what type and how much fertilizer should be used once the data has been preprocessed.

The model considers data from the weather API and the recommended quantity of fertilizer to decide whether or not to apply it. The farmer will get a message with the relevant information.

The usage of an ANN idea in creating smart fertilizer is shown in Figure 1. The prototype is equipped with a variety of sensors that map out the topography. After all the data is analyzed, an ANN model will provide a suggestion as to what goes into the best fertilizer. With the help of weather predictions available via a standardized API, fertilizer applies at the optimum moment. In order to ensure precise fertilizer composition, a model artificial neural network (ANN) is trained using data collected in the past from different digital sources and surveys.

3.Results and discussions

3.1. Results

If strategy that was described earlier was implemented, then the procedure shown in

Figure 2 would be the one that would be carried out with the assistance of the professionals and the farmers working together to bring it to a successful conclusion. This method would be carried out with the stages carried out in the sequence that was supplied. When attempting to build the manure composition characteristic by utilizing the data that has been supplied, the whole collection of data is utilized as a component of the procedure. This ensures that the best possible result is achieved. This guarantees that the outcomes will be as good as they possibly can be. This is because the strategy makes use of all of the information that has been acquired, which is the primary reason for this outcome. The information that the farmer would find useful is entered into the system, where it is not only stored but also maintained current so that it can be used in the future as a source of reference if necessary. In the past, evidence has been uncovered that chronicles the availability of nutrients in a certain environment. This piece of evidence was discovered at an earlier time. It was found that this piece of proof existed. After the data has been acquired by the sensors, it is then transferred to a server that is situated somewhere else on the internet. The sensors are used to collect data on a variety of features of the soil. The gathered measurements and the information from the system's previous iterations are both put through preliminary processing before being used in the production of estimates on the availability of nutrients and suggestions for fertilizer that are in accordance with the upcoming weather prediction. These estimates and recommendations will be used to advise agricultural decisions. This processing happens before the data is utilized in any way. The forecast for the future weather will act as the basis for these estimates and recommendations that have been provided. When anything like this is done, it is done in conjunction with the information that was obtained at the time that it was being gathered, and when it is done, it is done in combination with everything that was done. The results are sent to the farmer at his location in the form of a message that is delivered across a computer network. The message contains the findings.

The importance of feature extraction from data to improve the performance of artificial neural networks is seen in Figure 2 of the same research. In this visual representation, we can see how the data collected for the purpose of training the neural network was structured. These data specifics are crucial inputs that help the network learn and make predictions. The network may learn how to calculate the optimal manure-to-crop ratio given a set of inputs, such as the quality of the data. Soil composition data collection requires researchers to craft survey questions in order to glean useful information from the replies of the farmers questioned. By integrating the use of characteristics of the received data with the information retrieval process, the ANN is able to maximize agricultural yields.

Figure 2, which offers an overview of the process, depicts the extraction of data characteristics that will later be employed in the creation of a synthetic neutral network. These data features will be used in the building of the network. This figure also provides a synopsis of the method that was followed.

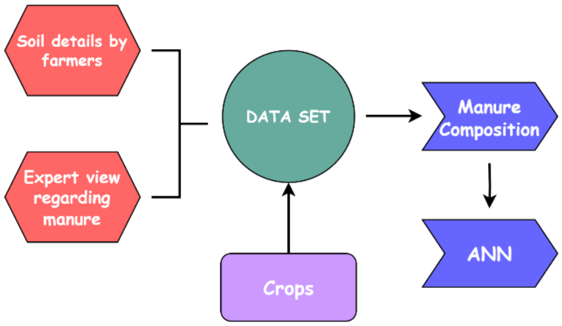

Figure 2. Retrieval of features from information for ANN.

The construction of the network will, in a variety of different ways, take advantage of the data qualities at hand. In order to get the most out of a given crop and the greatest potential outcomes from it, you will need to know what ratio of manure you should apply to it, and the findings will tell you what that ratio should be. Pay close attention to the findings if you want to get the most out of a crop and the greatest potential outcomes from it, both of which can be accomplished if you pay attention to the findings. The farmers are going to be questioned in order to collect information from them on the composition of the soil, and the questions that are asked of them are going to be geared toward them. Table 1 contains the information that the farmers contributed in the form of letters that they sent in, and this information can be found in the table. The information was acquired from a questionnaire pool that the framers hadprovided, and the questionnaire pool had a representative sample of one thousand different responses to the questions. It was successful in gathering the information. The additional data on the same kind of soil that was supplied by professionals working in the relevant field can be found in Table 2, which can be viewed below. The experts that are currently working in the field prepared this material for your benefit. When efforts are made to develop forecasts regarding the utilization of fertilizer in the future, it is very conceivable that the repercussions of these data will be taken into account.

Table 1. The Ground Truth.

Constituents of Mud	Total %
Dust	62.1
Mud	30.5
Soil	12.4

Table 1, which may be obtained by following this link, presents a comprehensive breakdown of the primary components that are responsible for the formation of soil. Because soil is naturally composed of a vast variety of different kinds of particles in a wide variety of sizes and shapes, it naturally contains a huge diversity of these particles. This is because the natural make-up of soil includes a varied change of diverse types of particles and forms.

Table 2. The opinions from dirt experts.

Substance belongings	Total
PH	5.13
Organic matter	3.14
Obtainable N	2.0
Obtainable P	330

Table 2 provides an analysis of the percentage of numerous soil physiochemical parameters that all play an important part in predicting the crop's yield. The percentages of these characteristics are detailed below. Because optimizing yield is so crucial, this function is crucial. Expert opinion on soil issues was gathered via in-depth interviews and conversations with people in relevant professions. These professionals evaluated the substance and assigned grades depending on a number of criteria, including pH, organic matter, available N (nitrogen), and attainable P (phosphorus). Table 2 displays the totals, as determined by the experts, for each category of drug. The figures in the table were calculated using the data given by the experts. By adhering to these procedures, we were able to compile the following table, which represents the collective knowledge of soil specialists. This table will serve as a guide for deciding what to track and how to track it in order to achieve sustainable agriculture.

Table 3 displays the results of an ANN analysis performed using Tables 1 and 2 as inputs. These are the results that are most closely associated with manure. Everything is counted on and then compared to the easily available expertise for purposes of comparison. Table 3 displays the results of an ANN analysis estimating the garbage's nutritional composition. Organic matter, total nitrogen, total phosphorus, total zinc, total copper, and total manganese are among the substances included. Here is a rundown of useful substances that might be present in manure. The numbers represent the concentrations of various components in the trash and their possible effects on plant growth. The accuracy of the prediction was assessed by comparing the findings to projections given by soil scientists. Ten separate experiments were performed to determine the forecast's reliability. The possible agronomic advantages of the garbage and its nutritional composition are detailed in Table 3.

Table 3. The nutrient profile of waste was estimated using ANN**.**

Substance belongings	Total
Organic Matter	41.3
Total N	7.58
Total P	5.00
Total Zn	250
Total Cu	48
Total Mn	510

The aforementioned computation comes quite close to matching the figure calculated by soil specialists. As a direct result, 10 separate experiments were conducted to evaluate the precision of the forecast. The results of these tests are shown in Figure 3, along with a description of the results. Considering the little percentage discrepancy between an expert's prediction and an ANN's estimate of the amount of organic matter needed, it would be absurd. The likelihood of an expert's forecast being right is higher than that of an ANN's estimate being correct. As was to be expected, increasing the productive potential of agricultural land that has been assigned, particularly for the task at hand, is a direct result of using the ANN prediction technique. Results are shown in Figure 4; Boosting agricultural land production for precision farming. The use of the prototype is directly responsible for the increased production. Since greater agricultural output is evident, this may be seen as a direct outcome of that. There was a noticeable uptick in output after implementing the prototype, and this increase may be clearly attributed to its adoption. Experiments of several types have been conducted to evaluate the ANN-based model and compare its results to those predicted by subject-matter experts. Figure 3 displays the results of these tests and includes a description of the information that may be gleaned from analyzing them. Multiple analyses were conducted to verify the accuracy of the model's predictions.

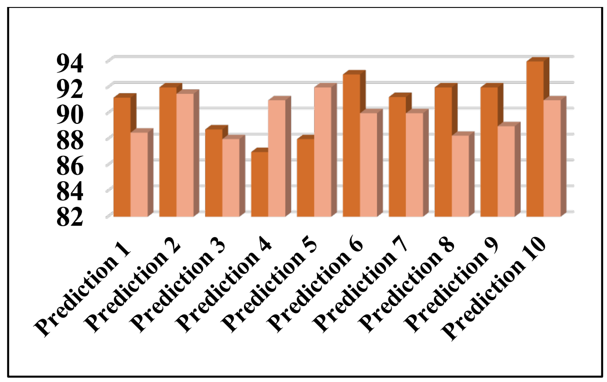

Figure 3: An Investigation at ANN and Experts Predictions.

Figure 3 depicts the test findings, including the most important factors. The quantity of organic matter needed is estimated by an ANN and then compared to a forecast given by a human expert. The picture draws emphasis on the percentage difference between the expert's prediction and the estimate supplied by the ANN, proving that the expert's prediction is more reliable. More importantly for our discussion, the graphic depicts how the ANN prediction approach may be used to increase the productive capacity of agricultural land. Farmers are polled to determine soil quality, and the results of these surveys need analysis. By incorporating the use of elements of the obtained data into the process of obtaining information, the ANN is able to maximize agricultural output.

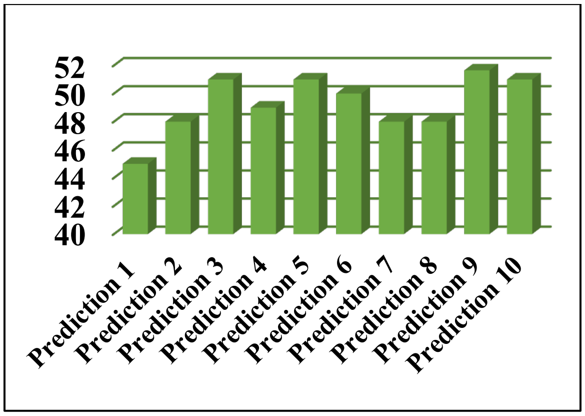

Figure 4. Boosting agricultural land production for precision farming.

Figure 4 shows how modern farmers are using precision agriculture to boost yields. Precision farming often employs cutting-edge technology and data analytics to get optimal results. This allows for control that is more precise and the potential for agricultural operations to be optimized in specific areas. Using tools like GPS, remote sensing, and data analytics, "precision farming" aims to boost yields while decreasing wastage and protecting natural resources. The value and potential use of these strategies for increasing agricultural output via the application of precision farming are shown in Figure 4.

3.2. Discussions:

In this part, we will examine the destinations and questions produced in contrast to the outcomes of the established arrangement. The primary purpose was to argue for the best compost treatment and time of application according to climate and to propose a method for assessing the amounts of nitrogen, phosphorus, and potassium (NPK) in the soil. The major goal was also to provide a technique for determining roughly how much NPK (nitrogen, phosphorus, and potassium) is present in the ground. The amount of each macronutrient was calculated by an ANN analysis performed for the program. Soil sensors installed around the region provided additional data in the form of temperature and pH measurements (Doukovska, 2021). If the problem statement's assertion is correct, then this model is an improvement over prior frameworks for determining soil compatibility and fertilizer recommendations, and it helps farmers overcome the difficulties they face in making this decision. The issue statement explicitly said this. This method closes the information gap by allowing farmers to quickly identify crop deficiencies and implement appropriate solutions. The void may be filled. This avoids the need for moving soil samples to other research institutes for testing and waiting for results, both of which might introduce errors into the ripeness administration process (Martos et al., 2021). Additionally, it lessens the potential for soil contamination. This eliminates the need for guesswork or gut feelings, as well as the practice of switching manure suggestions from farmers to ranchers.

By evaluating massive volumes of data, such as the previous performance of crops, weather patterns, soil conditions, and the frequency of pests and diseases, AI and big data analytics aid in the development of tailored and targeted crop management methods. The application of these technologies has the potential to uncover patterns and correlations, which might result in more precise recommendations for certain environments and crop kinds. When to plant seeds, how much fertilizer to use, how frequently to water, and what pests to keep an eye out for are just some of the questions that may be answered by machine learning algorithms, which can analyze and grasp massive amounts of data. This data-driven method streamlines operations reduces wastage, and boosts agricultural productivity and sustainability.

This is because there is so much data accessible right now. This helps to clarify why adjustments should be made to fertilizer regimens in order to better serve the requirements of crops and places and to protect the atmosphere via tumbling litter begun thru the dumping of excess fertilizer. In particular, this clarifies why fertilizer regimens must remain modified toward better meet the needs of convinced produces and geographic areas (Pallathadka et al., 2023). Even if the study shows that ANN works better than other methods for "smart farming" to determine the optimal fertilizer arrangement aimed at plants then mud, there are still major drawbacks to consider.(1) The nitrogen, phosphorus, and potassium (NPK) content of composts will be the primary focus of this discussion. These three substances make up the majority of compound composts and are therefore categorized as macronutrients. Since not all farmers are tech-savvy and not all farmers have smartphones, they offers outline designed for illustrative purposes, to enroll and modify landowner information, and to monitor device interpretations because they recognize and accept this reality. This is why the framework is developed by the interatomic chairman. (3) For this study, we accessed a database of environmental information through an electronic library. The model's forecast was very sensitive to the temperature, pH, and nitrogen, phosphorus, and potassium levels in the samples. Researching many crop fertilizer suggestions was recommended as part of the proposed strategy (Galaz et al., 2021). The following new criteria may be added to the model in the future as a result of research.

4. Conclusions

Big data analytics and artificial intelligence have a significant amount of potential for the goal of increasing agricultural yields and supporting farming practices that are nicer to the environment, and it is possible to draw the conclusion that these two fields have a great deal of promise for these purposes. This is due to the fact that it is projected that the global population will continue to expand, which will, in turn, result in an increasing need for food. The reason for this is that experts believe that the total number of people living on the globe will continue to increase in the coming years. Farmers and other stakeholders in the agricultural value chain are now able to make informed choices throughout the entirety of the agricultural value chain, beginning with the selection of seeds and ending with the harvesting of crops. This is made possible by the predictive capabilities provided by these technologies.

There is a lot of potential in using AI and data analytics on massive datasets to increase agricultural output in a sustainable way. These developments may result in improved choices, more effective use of resources, and increased productivity with less waste and pollution. However, in order to put AI into reality, we now need to collect massive amounts of data, face the difficulty of integrating data and developing standards and have certain expertise. Progress has been achieved in areas such as artificial intelligence (AI) algorithm development, sensor technology, and data management systems, which is positive despite the necessity to overcome these obstacles. Agriculture that is less taxing on the environment and on available resources may be possible with the widespread use of artificial intelligence and big data analytics.

This capacity to make educated decisions spans the whole agricultural value chain, starting at the very beginning and continuing all the way through to the very end. It is crucial for farmers to have the ability to make educated judgments throughout the whole process, starting with the selection of their seeds and continuing all the way through to the harvesting of their crops. It is now possible, thanks to the application of artificial intelligence and big data analytics, to achieve advances in a variety of sectors, including crop management, resource allocation, and risk reduction, to mention a few of these areas amongst others.

These are just some of the many areas that might benefit from these kinds of advancements. On the other hand, it is essential to recognize the limitations of artificial intelligence, such as its reliance on correct data, the possibility of bias in algorithm design, and the need for human expertise. It is quite necessary to acknowledge that one is bound by some restrictions. In order to overcome these challenges and realize AI's full potential, stakeholders need to take responsibility for ensuring that artificial intelligence is deployed and maintained in an appropriate way. The full potential of AI will be realized as a result of this. When used in the agri-food industry, the application of artificial intelligence and big data analytics provides the way for the construction of an agricultural system in the future that is both more robust and more efficient. It is very necessary to keep adding soil amendments on a regular basis in order to keep the soil quality at a high level and to ensure that there will be a continuous production of biomass over a lengthy period of time. This is the situation regardless of whether or not the soil quality is maintained at a high level. In addition to a rise in the concentrations of nitrogen and phosphorus that were already present in the soil before the application of natural fertilizer, the usage of natural fertilizer led to an increase in the concentrations of essential cations in the soil, which led to an overall increase in the concentrations of nitrogen and phosphorus in the soil. It is possible to draw parallels between the development of yellow poplars that have been given natural fertilizer and the growth of trees that have either been treated with NPK compost or natural fertilizer.

This is because natural dung is made from the waste products of animals, and the nutritional profiles of natural fertilizers are not the same as those of synthetic fertilizers. As a result, natural dung has a lower nutrient content than synthetic fertilizers. Laboratory work has resulted in the development of synthetic fertilizers. In this piece of research, a method is detailed that makes use of sensor data in order to offer projections about the concentrations of macronutrients and provide suggestions for fertilizer. The goal of this strategy is to improve agricultural production. The exploration of the influence that fertilizer has on the growth of plants was the fundamental reason for the execution of this strategy, which was utilized in order to examine the effect that fertilizer has on the development of plants. This makes certain that the treatment is carried out in the most effective way possible, taking into consideration the climatological circumstances that are currently taking place in the region.

In order to accomplish this goal, the timing of the fertilization procedures is coordinated in such a way that it correlates with the circumstances that are predicted to be present in the environment. This ensures that fertilization is carried out in the most effective manner possible. Administrators, farmers, and agricultural organizations may be able to get access to apps that are helpful to their respective industries if they make use of sensors that are linked to the Internet of Things (IoT). This is because "smart farming" refers to the practice of adopting practices that are both more precise and less resource-intensive. It will be vital in the future to have data that is not only freely available but also of high quality in order to be able to deliver advantages to farmers. The construction of a system architecture that is both strong and efficient will be greatly aided by the development of secure computer systems.

References

Alibabaei, K., Gaspar, P. D., & Lima, T. M. (2021). Crop Yield Estimation Using Deep Learning Based on Climate Big Data and Irrigation Scheduling. *Energies*, *14*(11), Article 11.

Alreshidi, E. (2019). Smart Sustainable Agriculture (SSA) Solution Underpinned by Internet of Things (IoT) and Artificial Intelligence (AI). *International Journal of Advanced Computer Science and Applications*, *10*(5).

Andronie, M., Lăzăroiu, G., Iatagan, M., Hurloiu, I., & Dijmărescu, I. (2021). Sustainable Cyber-Physical Production Systems in Big Data-Driven Smart Urban Economy: A Systematic Literature Review. *Sustainability*, *13*(2), Article 2.

Delgado, J. A., Short, N. M., Roberts, D. P., & Vandenberg, B. (2019). Big Data Analysis for Sustainable Agriculture on a Geospatial Cloud Framework. *Frontiers in Sustainable Food Systems*, *3*.

Doukovska, L. (2021). Artificial Intelligence to Support Bulgarian Crop Production. *Engineering Sciences*, *LVIII*.

Eli-Chukwu, N. C. (2019). Applications of Artificial Intelligence in Agriculture: A Review. *Engineering, Technology & Applied Science Research*, *9*(4), 4377–4383.

Galaz, V., Centeno, M. A., Callahan, P. W., Causevic, A., Patterson, T., Brass, I., Baum, S., Farber, D., Fischer, J., Garcia, D., McPhearson, T., Jimenez, D., King, B., Larcey, P., & Levy, K. (2021). Artificial intelligence, systemic risks, and sustainability. *Technology in Society*, *67*, 101741.

Ganeshkumar, C., Jena, S. K., Sivakumar, A., & Nambirajan, T. (2021). Artificial intelligence in agricultural value chain: Review and future directions. *Journal of Agribusiness in Developing and Emerging Economies*, *13*(3), 379–398.

Guo, T., & Wang, Y. (2019). Big Data Application Issues in the Agricultural Modernization of China. *Ekoloji*, *28*(107), 3677–3688.

Harfouche, A. L., Jacobson, D. A., Kainer, D., Romero, J. C., Harfouche, A. H., Scarascia Mugnozza, G., Moshelion, M., Tuskan, G. A., Keurentjes, J. J. B., & Altman, A. (2019). Accelerating Climate Resilient Plant Breeding by Applying Next-Generation Artificial Intelligence. *Trends in Biotechnology*, *37*(11), 1217–1235.

Holzinger, A., Keiblinger, K., Holub, P., Zatloukal, K., & Müller, H. (2023). AI for life: Trends in artificial intelligence for biotechnology. *New Biotechnology*, *74*, 16–24.

Javaid, M., Haleem, A., Khan, I. H., & Suman, R. (2023). Understanding the potential applications of Artificial Intelligence in Agriculture Sector. *Advanced Agrochem*, *2*(1), 15–30.

Kakani, V., Nguyen, V. H., Kumar, B. P., Kim, H., & Pasupuleti, V. R. (2020). A critical review on computer vision and artificial intelligence in food industry. *Journal of Agriculture and Food Research*, *2*, 100033.

Khan, N., Ray, R. L., Sargani, G. R., Ihtisham, M., Khayyam, M., & Ismail, S. (2021). Current Progress and Future Prospects of Agriculture Technology: Gateway to Sustainable Agriculture. *Sustainability*, *13*(9), Article 9.

Linaza, M. T., Posada, J., Bund, J., Eisert, P., Quartulli, M., Döllner, J., Pagani, A., G. Olaizola, I., Barriguinha, A., Moysiadis, T., & Lucat, L. (2021). Data-Driven Artificial Intelligence Applications for Sustainable Precision Agriculture. *Agronomy*, *11*(6), Article 6.

Martos, V., Ahmad, A., Cartujo, P., & Ordoñez, J. (2021). Ensuring Agricultural Sustainability through Remote Sensing in the Era of Agriculture 5.0. *Applied Sciences*, *11*(13), Article 13.

Misra, N. N., Dixit, Y., Al-Mallahi, A., Bhullar, M. S., Upadhyay, R., & Martynenko, A. (2022). IoT, Big Data, and Artificial Intelligence in Agriculture and Food Industry. *IEEE Internet of Things Journal*, *9*(9), 6305–6324.

Nasirahmadi, A., & Hensel, O. (2022). Toward the Next Generation of Digitalization in Agriculture Based on Digital Twin Paradigm. *Sensors*, *22*(2), Article 2.

Pallathadka, H., Mustafa, M., Sanchez, D. T., Sekhar Sajja, G., Gour, S., & Naved, M. (2023). IMPACT OF MACHINE learning ON Management, healthcare AND AGRICULTURE. *Materials Today: Proceedings*, *80*, 2803–2806.

Saiz-Rubio, V., & Rovira-Más, F. (2020). From Smart Farming towards Agriculture 5.0: A Review on Crop Data Management. *Agronomy*, *10*(2), Article 2.

Sánchez, J. M., Rodríguez, J. P., & Espitia, H. E. (2020). Review of Artificial Intelligence Applied in Decision-Making Processes in Agricultural Public Policy. *Processes*, *8*(11), Article 11.

Sharma, R., Kamble, S. S., Gunasekaran, A., Kumar, V., & Kumar, A. (2020). A systematic literature review on machine learning applications for sustainable agriculture supply chain performance. *Computers & Operations Research*, *119*, 104926.

Streich, J., Romero, J., Gazolla, J. G. F. M., Kainer, D., Cliff, A., Prates, E. T., Brown, J. B., Khoury, S., Tuskan, G. A., Garvin, M., Jacobson, D., & Harfouche, A. L. (2020). Can exascale computing and explainable artificial intelligence applied to plant biology deliver on the United Nations sustainable development goals? *Current Opinion in Biotechnology*, *61*, 217–225.

Talaviya, T., Shah, D., Patel, N., Yagnik, H., & Shah, M. (2020). Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides. *Artificial Intelligence in Agriculture*, *4*, 58–73.

Zhang, P., Guo, Z., Ullah, S., Melagraki, G., Afantitis, A., & Lynch, I. (2021). Nanotechnology and artificial intelligence to enable sustainable and precision agriculture. *Nature Plants*, *7*(7), Article 7.