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Research Article

Selection of Smart Manure Composition for Smart Farming Using Artificial Intelligence Technique

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A modern worldview has developed in rural methods, devices, and advances. Exactness in agribusiness is required to guarantee site-specific editing of administration, which incorporates soil supplement arrangements that are custom fitted to each crop's needs. In spite of the fact that preparation is vital for expanding efficiency, it is vital to dissect the possibilities and impediments of soil as a premise for selecting the correct manure sort, amount, and application time to dodge compost utilization instability. Farmers' dependence on instinct, trial and mistake, mystery, and assessing significantly includes major wasteful aspects such as efficiency misfortunes, asset squandering, and expanded natural defilement due to the complexity of deciding the perfect preparing extend. Agriculturists cannot successfully estimate the impacts of their choices on yield and the environment when utilizing these. This paper illustrates why manure regimes should be adjusted to meet the demands of certain crops and regions, as well as to safeguard the environment by reducing pollution caused by fertilizer and manure waste. A few soil-richness administration strategies, such as the utilization of versatile research facilities or imported gear, have confronted obstacles in terms of fetched, comfort of utilization, and adaption to the neighborhood environment. Other choices, such as sending soil to research facilities for testing, are badly designed, time-consuming, and conflicting. Based on the climate estimate, this thing should be suggested according to the development of an ANN and show the estimates of NPK supplement levels and offer the fitting compost treatment and application timing.

1. Introduction

Plant development and soil fertility are both aided and harmed by chemical fertilizers and organic manure. Chemical fertilizers are affordable, high in nutritional content, and easily absorbed by plants [1]. Since its inception, the Internet of Things (IoT) has had a significant impact on agriculture. Agriculture has experienced a fourth revolution (Agricultural 4.0) in recent years as information and communication technology (ICT) has been integrated into traditional farming practices. Remote sensing data, the Internet of Things (IoT), unmanned aerial vehicles (UAVs), Big Data Analytics (BDA), and machine-learning (ML) are all potential farming tools [2, 3]. Excess fertilizer, on the other hand, can lead to nutrient loss, contamination of surface and groundwater, acidification or basification of soil, loss of helpful microbial populations, and increased sensitivity to destructive insects. When compared to chemical fertilizers, organic manure has a number of disadvantages, including poor nutrient concentration, delayed breakdown, and varied nutritional contents depending on organic source [4, 5]. A wide range of agricultural characteristics, such as environmental conditions, growth state, soil status, irrigation water, pest and fertilizers, weed control, and greenhouse production environment, can be monitored in smart farming to improve crop yields, reduce costs, and optimize process inputs [6, 7]. Organic manure is widely used in agriculture due to a large number of advantages, which include increased nutrition to the soil due to involvement of microbiological activities, helping in balancing the soil nutrition, helping to decompose the harmful material present in the soil, enhancing the soil inner structure while helping root development, and lastly, increasing the water level presence in the soil [8].

Smart farming solutions based on the Internet of Things (IoT) are a system that monitors the agricultural field and automates the irrigation system using sensors (light, dampness, heat, moisture content, crop growth, and so on). Farmers can monitor their fields from just about anywhere. The Internet is among the most innovative wireless communication technologies in modern times. The essential idea is that numerous entities interact with one another. Physical things or items must employ certain addressing techniques in order to connect to the Internet. IoT technology has the potential to be employed in a wide range of industries. Agriculture markets include industry, transportation, healthcare, automobiles, and smart homes, to name a very few [9, 10]. Soil fertility is one of the many factors that influence agricultural productivity. Soil fertility is a critical component of agriculture, and it is influenced by a number of factors, including environmental, human, and biotic factors, all of which affect nutrient levels and crop health sustainability [11]. Nutrient release from fertilizers is influenced by soil PH, soil temperature, microbial activity, and moisture content. To ensure maximal consumption, precise measurements of the aforementioned ingredients indicate the amount of fertilizers to be added to the supplement and the timing of administration [12]. Because rain or sunshine affects nutrient flow in the soil, the weather plays an important role in determining when to apply [13, 14]. Nowadays, farmers are more in touch with organic fertilizers. Organic fertilizers endure longer than synthetic fertilizers because they supply critical nutrients to growing plants while also replenishing the planet. Organic fertilizers include a well-balanced mix of nutrient sources required by soil bacteria and earthworms. Agriculture has gone through several revolutions, including the domestication of animals and plants thousands of years ago, the systematic use of crop rotations and other improvements in farming practice a few hundred years ago, and the "green revolution" for systematic breeding and widespread use of man-made fertilizers and pesticides a few decades ago. We believe agriculture is witnessing a fourth revolution as a result of the rapidly increasing use of information and communication technology (ICT) in agriculture [15, 16]. To assist farmers in understanding their farm needs, a variety of solutions have been developed and implemented. Other than home cures, some people employ agricultural labs testing, mobile laboratories tests, and smart systems. Each has its own set of issues that make it tough for the farmer to use [17]. The goal of this research is to develop a model that checks NPK levels based on variables such as PH and temperature and recommends fertilizer to farmers as well as the best time to apply it in order to avoid fertilizer burn, leaching, wash off, gentrification, and volatilization, all of which are caused by unpredictable weather conditions such as sunshine and rain [18]. When it comes to growing, smart-farming approaches may be significantly more exact. Fewer passes are necessary to complete a task when overlaps are removed, reducing the total distance traveled by the tractor to complete the process. Over and under spraying degrades crop quality, resulting in uneven regions of scorched plants and stunted underperforming plants. Farmers may utilize Section Control to produce dependably equal and healthy crops while increasing yields by reducing over- and underlapping. Smart agriculture, on the other hand, needs constant Internet access. Most developing countries' rural areas do not meet this condition. In addition, the Internet connection is slower. Farmers may benefit more from agriculture if they employ smart agricultural strategies. Farmers will save money and labor by minimizing resource inputs and dangers will be decreased by increasing the dependability of spatially explicit data. Based on a comprehensive network of meteorological and climate information, optimum, personalized weather predictions, yield estimates, and likelihood maps for illnesses and calamities will enable for optimal crop production. Furthermore, site-specific data enables new security and economic possibilities for the entire value chain, from technology and input providers through farmers, processors, and merchants in both developing and developed countries [19, 20].

With a growing global population, pressure on global food systems will increase, and agriculture will confront the challenge of guaranteeing food security for a growing global population while also protecting environmental security. As a result, modern technologies in agroecosystems will be necessary to produce enough food while minimizing the negative environmental impacts of chemical fertilization and insufficient disposal or reuse of agricultural waste. The research presented here introduces a novel strategy for determining manure composition for soil that improves productivity while simultaneously conserving the soil.

2. Literature Review

Natural manure derived from animal waste has long been used in agricultural fields to offset pollution and plant productivity losses caused by chemical fertilizers [21]. As a result of recycling manure, the environment is protected and treatment costs are lowered, while at the same time, soil is improved and crop yields are increased. However, it is unclear what effects are achieved when chemical fertilizer and organic manure are combined [22].

Furthermore, sensor technologies that collect data from the soil, crop, different environmental conditions, animal behavior, and machinery condition are required for smart farming. Such sensor data, through edge IoT computing and analytics, may provide critical information to farmers on weather conditions and projections, crop monitoring and yield prediction, animal and plant disease detection, and more [23, 24]. In soils enriched with nitrogen, phosphorus, and potassium through the mixed application of nitrogen phosphorus potassium chemical fertilizer and livestock organic manure, mint (*Mentha arvensis*) and mustard (*Brassica juncea*) hold significant higher growth rates by 46% and 36% higher soil nitrogen, phosphorus, and potassium concentrations, 129% and 65%of respondents do, respectively [25]. Research presented in [26] compared chemical fertilizers only with chemical fertilizers and organic manure in sorghum (*Pennisetum glaucum*) growing on farmland in addition to organic manure enhanced soil concentrations of organic carbon, nitrogen, phosphate, and potassium, underscoring the importance of organic manure in tropical agriculture [27].

There have been many studies in the field of forestry, but there have been less in the sector of agriculture. A study conducted on a short-rotation willow (*Salix dasyclados)* plantation in the Middle-East region of North America revealed soil concentrations of potassium, phosphorus, and magnesium, utilizing slow-acting chemical fertilizer and organic cattle manure. In a poplar manor in clay soil, be that as it may, [28] found that chemical composts empower way better development and root advancement than cattle natural fertilizer. Soil supplement administration is basic for keeping up reliable tall biomass efficiency and preparation in that as it were implies to supply soil supplements in a convenient way. Fertilization costs contributed to about 20–30% of add up to generation costs in biomass generation, agreeing to [29]. The impacts of combining chemical compost and natural excrement on tree improvement and soil richness, on the other hand, change essentially depending on manure levels and natural excrement properties. The nitrogen concentration of natural fertilizer is what decides how much is required. Be that as it may, since the proportions of supplements other than nitrogen can contrast from the trees' prerequisites, more care must be taken.

Even though much of agriculture is informal and inefficient, the information technology sector sees the sector's latent potential by using ICT to formalize it [30]. Farmers learn how to embrace better farming techniques and unlock their potential to increase output by discovering knowledge from data and disseminating it to them. In all of these endeavors, sustainability is critical, necessitating the development of tools that are easily available, inexpensive, and user-friendly. Eliminating barriers that prevent higher productivity is one strategy to ensure increased production. It may be through removing the difficulties farmers face in getting consistent soil tests, weather forecasts, and other data that would help them make better decisions [31].

Precision farming may be a particular technique pointed at enhancing yields utilizing current innovation such as sensor innovations, GPS administrations, and big data optimization in an economical way to attain both quality and amount whereas too sparing cash. These empower for a more point by point understanding of a condition at the ground level, permitting for superior choices to be made in an arrange to realize most extreme productivity and limit asset squander [32]. These technologies help with data collection and processing so that information can be presented in a way that prompts appropriate responses. Smart farming can be implemented thanks to the use of sensors in agriculture.

3. Model Development Based on Artificial Neural Network

This section describes the process used for manure selection and composition using artificial intelligence technique. The ANN is used as AI technique to help the farmer for best possible solution. The following actions were taken to create the model. The details are described in this section.

3.1. Data Collection. The main source of data was soil data and fertility analyses acquired through surveys and government websites. These arrived in the form of laboratory soil records and agricultural magazines' nutrient management instructions. A dataset of 1000 sections with soil PH, temperature, and NPK values is collected. Understanding of the information and soil investigation rules presently connected was helped by discussion and assist dialog with soil specialists.

3.2. Data Preprocessing. The information was collected from the papers, such as association logs, and put away in basic exceed expectations pages. Information cleaning helped in recognizing the information required and expelling clamor and unessential information, especially captured factors not considered in this venture. For preparing, testing, and showing approval, all information is spared in its aggregate. This method was pivotal within the creation of precise and reliable models.

3.3. Model Training. Inputs are fed into the model for processing, and the model is trained on the input data and predicted output. Artificial neural networks were employed as the machine-learning algorithm. In order to arrange to decide the plausibility of evaluating exact compost measurements, the information sets were isolated into 75% preparing information and 25% testing information. The projected output of NPK soil levels for fertilizer recommendation was based on the inputs of soil temperature, PH, and NPK values.

3.4. Model Framework. The prototype is seen in Figure 1. The sensor's data are fed into the model. The model suggests the best fertilizer to use. An integrated weather API provides a weather forecast, which helps determine whether or not to fertilize. Historical data for model training comes from surveys and digital government sources.

Figure 1 is the ANN-based block diagram for smart manure composition. Through various sensors, the physiochemical properties of the soil will be checked and adequate composition will be added.

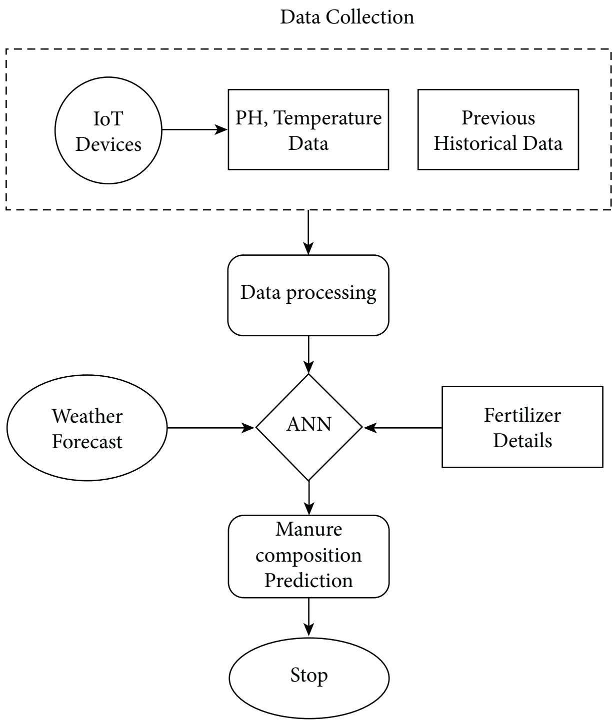

Figure 1: ANN-based prototype for smart manure composition.

3.5. Prototype Testing and Validation. The optimal combinations of temperature, PH, and NPK inputs were identified through many studies. The trials employed ANN, which was chosen as the single method due to the nature of the inputs and desired outcome. The capacity of ANN to memorize and mimic nonlinear and complex intelligent, which in this case would be the complex affiliation of diverse soil supplements with PH at different temperature levels, was the leading fit. It too works best when capturing relationships or regularities, such as the relationship between supplement accessibility and soil PH levels in this case. Temperature has an impact on these as well. It encompasses a wide range of interactions, including those between PH, NPK, and temperature.

The system architecture describes how the different system components work together to produce system functionality. The system architecture explains how the system must support the system's design, structure, and user needs. The subsystems and connections between them within the manure suggestion demonstration are portrayed in Figure 1. Clients, IoT apparatuses (temperature, PH Sensors, and Arduino), climate API, database or server, and the machine-learning model are all included within the proposed framework plan. The IOT Hubs (temperature, PH Sensors) are put over the cultivate to gather soil measurements, which are at that point communicated to a database and nourished into the machine-learning demonstrate. The preprocessor and an ANN classifier make up the machine-learning component. The data is preprocessed before being supplied to the classifier, which classifies the type and quantity of fertilizer to use. The model determines whether or not to fertilize based on the fertilizer recommended and weather API forecast data. This data are forwarded to the farmer.

4. Simulation Result

Figure 2 shows the approach of using the above methodology with the involvement of farmers and the expert. All the data are used for the manure composition feature extraction from the provided data set. The farmer's information is saved in the system. The availability of nutrients has been recorded in the past. Sensors capture soil parameters, which are then relayed to an Internet server. The acquired metrics, along with the system's history data, are preprocessed and used to anticipate nutrient availability and fertilizer recommendations based on forecast weather. The farmer receives the results in the form of an digital network message.

Figure 2 shows data feature extraction for artificial neutral network. It will evaluate the manure composition for particular field. The details of the soil will be received from the farmers. The data input given by the farmers are shown in Table 1. The data were taken from 1000 inputs given by the framers during the survey. Expert given details regarding the same soil is given in Table 2. All this information is used as historical data for manure prediction for the soil. Table 1 is the soil composition details. Since soil in itself is the mixture of various particles.

Table 2 discusses the percentage of various physiochemical properties of the soil which plays a crucial role in determining the output prediction of the crop. Using Tables 1 and 2 as input for the ANN technique, the outcome regarding the manure is given in Table 3. All the details are predicted and then compare with the expertise for the comparison.

The above-predicted value is almost the same as defined by the soil experts. So ten different trials were done to see the accuracy of the prediction and the result is shown in Figure 3. The expert and ANN prediction % is almost same for the organic matter required as per Table 3. The productivity of the given farming land is increased by using the ANN prediction method. Figure 4, shows the results which highlight the productivity that has increased in the farmland due to the use of the ANN-based prototype for manure production.

Various trials have been done for measuring and comparing the ANN-based model and prediction done by the experts. In Figure 3, these trials were done to ensure the accuracy of the model.

Figure 4 shows an increase in the productivity for various successful trials. It is clear from the bar a diagram that a good rate of yield was observed with the help of predicted model. This method will not only increase the yield but also helps to preserve the soil. It is clear from Figure 4 that there is an overall increase of approximately 50% in the farmland productivity by using the AI-based system for smart farming.

It is possible to assert that the proposed ANN-based method has a high potential for producing more productive and sustainable agricultural output through a more precise and resource-efficient approach. It offers value by facilitating better decision-making and is principally concerned with enhancing the production and preserving the soil content.

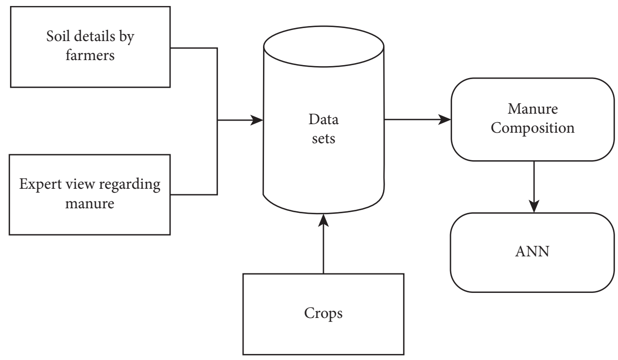

Figure 2: Data feature extraction for ANN.

Table 1: Soil details.

Soil composition	% Value
Sand	60.4
Silt	29.5
Clay	10.1

Table 2: Expert input regarding the soil.

Chemical properties	Value
PH	5.10
% Organic matter present	2.50
Available N (g/kg)	1.98
Available P (mg/kg)	310

Table 3: ANN predicted manure composition.

Chemical properties	Value
Organic matter required (%)	40.20
Total N required (g/kg)	8.82
Total P required (mg/kg)	6.00
Total Zn required (mg/kg)	200
Total Cu required (mg/kg)	45
Total Mn required (mg/kg)	500

5. Discussion

This section compares the results of the created arrangement to the destinations and inquire about questions built up in Section 1. The major objective was to make a show for foreseeing NPK levels in soil, as well as to endorse the ideal compost treatment and timing of application concurring on the climate. To assess the macronutrient levels, the show utilized an ANN calculation. Temperature and PH were two of the inputs from the soil sensors.

This model addresses the difficulties farmers encounter in finding the optimum fertilizer and improving existing frameworks for calculating soil suitability levels and fertilizer recommendations, as stated in the problem statement. The stated technique bridges the gap by permitting a agriculturist to rapidly distinguish a lack on their cultivate and apply the suitable arrangement, dispensing with botches in ripeness administration and the time-consuming strategy of transporting soil-to-soil research facilities for testing and holding up for discoveries. This moreover kills the requirement for speculating and instinct, as well as variable manure suggestions from agriculturist to rancher. This explains why fertilizer regimes should be changed to match crop and region needs, as well as to protect the ecosystem by lowering pollution produced by fertilizer waste.

Although the research highlights the better performance of ANN used for smart farming to get best manure composition for the crops and soil, it has some limitations which are stated below:

(1) The consideration is centered on NPK composts, which contain NPK, the macronutrients that make up the larger part of compound composts.
(2) They think and accept that not all agriculturists are tech-savvy or have smartphone to get to it, as a result, the chairman of the interatomic designs the framework for illustration, to enroll and overhaul rancher data, as well as to screen sensor readings.
(3) This investigation employed environmental accessible samples from the online library, which included temperature, PH, and NPK values, all of which had a significant impact on the model's prediction outcomes.

The proposed system investigated crop fertilizer recommendations. Future research can improve the model and integrate more requirements:

(1) The established model could be improved to include study of other environmental parameters, soil conditions, and fertilizer use in order to advise fertilizer producers on which fertilizers to produce instead of general fertilizers in order to fully protect the ecosystem.
(2) Future inquiry about all this may see at components within the soil that cause supplement exhaustion and come up with ways to dodge making a comfortable environment for their event, such as aluminum and sodium, and how water system and filtering can offer assistance and get freed of abundance supplement components or the said unsafe components.

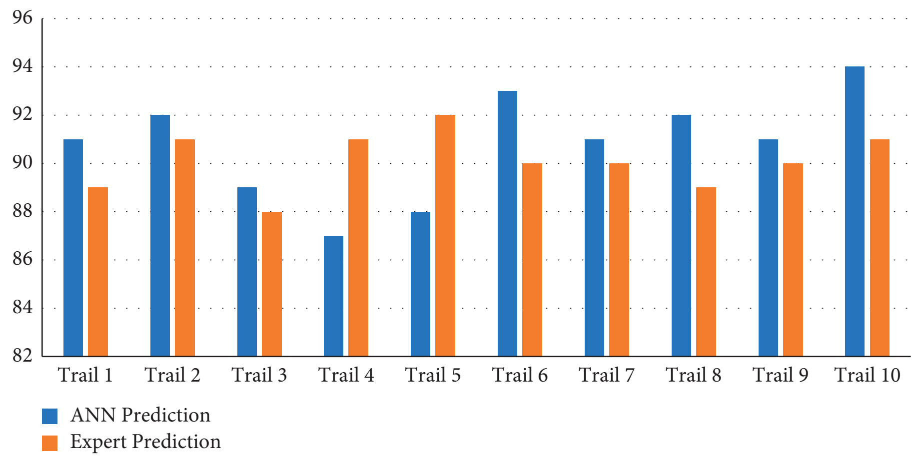

Figure 3: ANN prediction comparison with expert prediction.

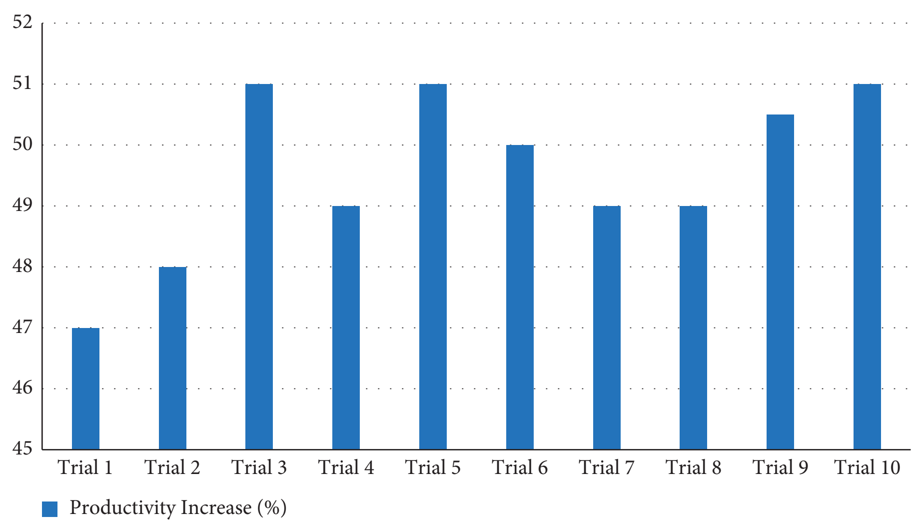

Figure 4: Productivity increase in the farmland for smart agriculture.

6. Conclusion

Soil supplement administration is basic for long-term biomass generation and soil quality conservation. Natural fertilizer raised soil pH, nitrogen, phosphorus, and major cation concentrations. The development of yellow poplars after being treated with natural fertilizer is comparable to that after being treated with NPK compost. Earlier to applying natural excrement determined from animals' by-products, it is critical to consider the distinctive supplement compositions of the natural fertilizers based on the sorts of animal's by-products, the soil properties of the application lands, the supplement prerequisites of the target tree species, and the natural and sterile conditions within the encompassing regions. The model proposed in this paper uses sensors to collect data for macronutrient level prediction and fertilizer suggestion. This guarantees that the correct medication is applied at the appropriate moment for the best weather conditions. This is accomplished by synchronizing fertilization regimens with weather patterns. Administrators, farmers, and agricultural organizations can all benefit from the usage of IoT sensors. Smart farming, on the other hand, has the potential to deliver more productive and sustainable agricultural output by employing a more precise and resource-efficient method. Future solutions will necessitate the availability and quality of data in order to aid farmers, and security will be essential in the creation of robust and efficient systems.

Data Availability

Data will be made available on request.

Conflicts of Interest

There are no conflicts of interest regarding the publication of this paper.

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