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IoT and AI Enabled Framework to Monitor Soil and Crop Health for Sustainable Development in Precision Farming-A Study

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ABSTRACT: Emerging technologies like Internet of Things (IoT) and Artificial Intelligence (AI) play a significant role in the automation of processes and improving quality of life in terms of sustainable livelihood. The significance of these technologies extends to every domain we can think of. The use of IoT and AI have helped in relieving the farmers risk and enhancing the crop productivity. The World Population Data Sheet 2022 indicates that the global population could grow to around 8.5 billion in 2030, and add 1.18 billion in the following two decades, reaching 9.7 billion in 2050 and the global demand for food which anticipated to grow 70% by 2050. Expected food supply, land requirement to fulfill this demand and reduction in emission are some major challenges. Therefore, increasing and improving the quality of the crop yield is a major field of interest. It is necessary to change the traditional methods and procedures employed in agriculture to satisfy the global demand for food. This paper underlined the comparative analysis in conjunction with an IoT enabled Framework to regulate Soil and Crop Health for sustainable development in precision farming using modern tools and technologies to mitigate challenges and opportunities.

Keywords: Precision Farming, IoT, AI, Cloud Computing, Sensors, Computer Vision.

INTRODUCTION

Agriculture is the most important sector of Indian economy and major source of livelihood for about 58% of Indian population. Traditional ways and techniques of farming are not adequate to fulfill the balanced nutritional food requirement of the country like India. To serve this growing demand, our farmers need to adopt the latest technological advancements in agriculture such as use of modern tools, equipment, IoT and Artificial Intelligence (AI) based techniques. Precision farming helps to utilize resources such as water, fertilizers and seed for sowing in a precise manner to increase the productivity with the least cost involvement.

It has been observed that majority of the farmers are not well versed regarding the appropriate and timely dose of fertilizers, pesticides etc. Due to the lack of knowledge, information, and bad practices; the fertility of the soil, quality of crops as well as yield degrades badly. Soil on the earth is very much essential for livelihood as it is a natural habitat for many insect species that find shelter and food for their life and living organisms including plants and animals that spent their whole life in soil that contribute a lot to enhance the fertility of it. They act as a purifier for the surface and ground water and maintains atmospheric gases like Nitrogen, Oxygen, Carbon dioxide etc. It is also a vital component for agriculture and responsible for crop yield. Physical and chemical characteristics of soil not only provide physical support and medium to roots of plants to get water and air for respiration but also supply essential nutrients required for the betterment of crop yield. The farmers must routinely evaluate these properties of the soil to perform corrective actions for the selection of suitable crop based on the soil condition and fertilizer requirement to protect their agri-fields to get higher productivity and profit. Nowadays, machine learning with big data analytics and high-performance computing generates new prospects in the multidisciplinary agri-technologies field.

IMPACT OF TECHNOLOGICAL DEVELOPMENT IN PRECISION FARMING

A. Sensing Technology

Sensing technology uses sensors to detect the physical, chemical, or biological property parameters and convert them into readable signal. In recent years, sensor technology has been emerging very fast with high accuracy, fast response, and stable output.

Sensors essentially perform very crucial and important role in precision farming to acquire soil, environment and plant related information and widely used in the agriculture field. Most important and commonly used sensors in this field are Soil Moisture Sensor, Temperature and Humidity Sensor, UV Sensor, NPK Sensor, pH Level Sensor, Rainfall Sensor, and Camera module.

B. Information Communication Technology

The specifics of information and communication technologies are covered in this subsection. The main factor in turning on the IoT framework is wireless communication systems. In view to accomplish end-to-end data transfers between various IoT components, these systems are used to link sensor devices to IoT gateways. Different wireless standards underlie wireless systems, and the adoption of each relies on the application's needs for things like communication range, bandwidth, and power consumption.

Hossein *et al.* (2020) extensively researched that how to use short-range wireless technologies, such as Wireless Fidelity (Wi-Fi), for IoT applications in the agriculture industry. However, Wi-Fi is not the optimum technology for this industry due to its high-power consumption. Better options for use in the agriculture industry include low power wide area network (LPWAN) communication technologies like LoRa, Sigfox, and LTE-M that operate in unlicensed bands, as well as established LPWAN technologies like ZigBee, Bluetooth low energy (BLE), and narrowband IoT (NB-IoT). Considering that these new LPWAN technologies make it possible to develop a dependable, affordable, low-power, long-range, last-mile technology for smart farm management systems.

A short-range wireless communication technique for the IoT, Bluetooth Low Energy (BLE) facilitates data exchange via brief radio waves. BLE allows the quick creation of a personal area network because it is less expensive to deploy and typically has a range of 0 to 30 m. BLE is designed for small-scale IoT applications that need low-power data communication between devices.

A communication technology called Zigbee aimed in developing small-scale applications and personal area networks. Zigbee is simple to set up and designed to offer inexpensive, low-data-rate, and extremely reliable networks for low-power applications. The mesh network specification used by Zigbee allows devices or nodes to connect to several other devices and are dynamically updated. The maximum communication range of Zigbee, which is up to 100 meters, is substantially increased by using the mesh networking feature.

IoT-focused wireless communication technology called Long Range (LoRa) was developed to enable real time communication. For widespread IoT deployment, LoRa is a cost-effective communication technology that can extend battery life by many years. Additionally, LoRa is employed to create awfully-power-efficient long-distance broadcasts (more than 10 km in rural regions). Due to its characteristics, this technology is a good communication tool for the agricultural industry.

Wide area network technology called Sigfox has advantage of an ultra-narrow spectrum. Sigfox allows low-power device communication for enabling IoT applications. Additionally, many low power wide area network technologies are compared in the study, and it is determined that Sigfox is a good option for use with electrical plugs and cautionary sensors in smart houses.

A vast number of IoT devices and services supported by the LPWAN communication technology known as narrowband IoT (NB-IoT), which has an extremely low latency and high data rate. A cheap solution with a long battery life and better coverage is NB-IoT. By offering low-cost communications for smart metres, NB-latency IoT's qualities make it a possible-solution for smart energy distribution networks.

Shi *et al.* (2019) reported that the third-generation partnership project (3GPP) standardised for Long Term Evolution for Machine (LTE-M) communications aims to simplify the hardware for machine-type communication (MTC). LTE-M delivers high system capacity, omnipresent coverage, and support for secure connection. Compared to NB-IoT, LTE-M also provides services with lower latency and better throughput. A potential option for smart metre and smart grid communications, this technology also offers energy-efficient resource allocation for small-powered devices.

In view to establish communication between IoT equipment and devices, the Weightless LPWAN open wireless standard was created. Smart metering for the energy industry may have an answer in Weightless. According to the study, Weightless is an appropriate wireless technology for usage in IoT applications for smart metres and smart grid communications in smart homes.

When compared to cable transmission technology, wireless communication technology offers the benefits of being less expensive to build and maintain, using less energy, and having superior extensibility.

ML ALGORITHMS AND AI TECHNIQUES

In this section, we have discussed machine learning algorithms and AI methods used in precision farming to increase crop productivity.

A. Classification of ML algorithms

Mohammed *et al.* (2016) stated that four broad categories can be used to classify machine learning algorithms: Reinforcement learning, semi-supervised learning, unsupervised learning, and supervised learning as shown in Fig. 1.

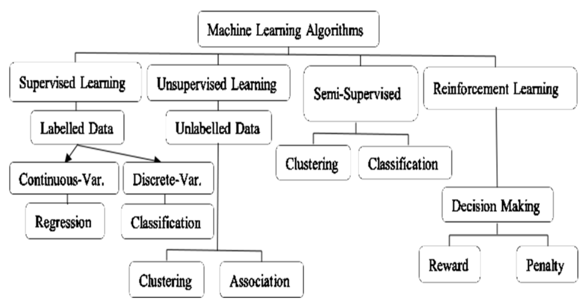

Fig. 1. Classification of ML Algorithms.

1. Supervised Learning: Typically, supervised learning involves using example input-output pairs to teach a function that maps an input to an output. To infer a function, it makes use of labelled training data and a variety of training samples.

2. Un-supervised Learning: Without the involvement of humans, or as a data-driven process, unsupervised learning analyses unlabelled datasets. This is frequently used to extract reproductive features, find significant patterns and structures, organise results, and conduct experimental work. The most typical unsupervised learning tasks are clustering, anomaly recognition, feature learning, dimension reduction, density assessment, and so on.

3. Semi-supervised Learning: Semi-supervised learning can be thought of as a crossbreeding of the supervised and unsupervised approaches as it uses both labelled and unlabelled data. It is therefore in the middle between studying "with supervision" and "without supervision" learning. Semi-supervised learning is helpful in situations when unlabelled data is abundant and labelled data is scarce in the actual world. A semi-supervised learning model's objective is to create predictions that are superior to those made using the model's labelled data alone. Semi-supervised learning is utilised in a variety of applications, including text categorization, machine transformation, and fraud finding.

4. Reinforcement Learning: Reinforcement learning is a form of machine learning technique that allows software tools and computer machines to automatically analyse the optimum performance in a certain situation or ecosystem to increase its efficiency as stated Kaelbling *et al*. (1996) and the process is known as an environment-driven approach. This kind of learning is based on reward or punishment, and its objective is to use the knowledge gained from environment protesters to take steps to either raise the reward or decrease the danger. However, it is not advisable to utilise it for resolving simple or elementary issues. It is a potent tool for training AI models that can help enhance automation or optimise the operational efficiency of complex systems like robots, autonomous driving activities, manufacturing, and supply chain logistics.

According to their learning capacities, various machine learning techniques can thus play a crucial part in the development of effective models in a variety of application areas, depending on the type of data being used and the desired result.

B. Machine Learning Techniques

Various machine learning techniques that have been used specifically in the disciplines of agriculture for classification, regression, and clustering analysis are briefly presented here:

1. Naive Bayes (NB): The naive Bayes algorithm is centred upon the Bayes theorem and assumes that each pair of characteristics is independent each other (Han *et al.,* 2011). It works well and may be applied to both binary and multi-class classes in a variety of real-world contexts, including spam filtering, document, or text categorization, etc.

2. Logistic regression (LR): Logistic Regression (LR) is another popular statistical model with a probabilistic foundation that is used to address classification problems in machine learning (LeCessie and Van Houwelingen 1992). In Logistic Regression, the sigmoid function is often referred to as the activation function. is defined as:

$f(x) = 1/(1 + e^{-x})$ (1)

where x is a real number variable.

3. K-nearest neighbours (KNN): The instance-based learning or non-generalizing learning algorithm K-Nearest Neighbours (KNN)is also referred to as a lazy learning algorithm (Aha *et al.,* 1991). Instead of concentrating on creating a broad internal model, it keeps all occurrences that correspond to the training set in an n-dimensional space. KNN makes use of data and categorises fresh data points using similarity metrics (e.g., Euclidean distance function). The major challenge with KNN is determining the ideal number of neighbours to consider them. KNN has applications in both classification and regression.

4. Support vector machine (SVM):A support vector machine (SVM) is yet another popular machine learning tool that can be used for classification, regression, or other tasks. A support vector machine builds a hyper-plane or set of hyper-planes in high- or infinite-dimensional space. Inferentially, the hyper-plane that is farthest from any class's nearest training data points produces a significant separation since, the lower the margin, the less accurate the classifier is at generalising its results. It works well in high-dimensional spaces and exhibits a variety of behaviours depending on the kernel, or set of mathematical operations, used. Popular kernel functions used in SVM classifiers include linear, polynomial, radial basis function (RBF), sigmoid, and others (John and Langley 1995). SVM operates poorly in situations where there is more noise in the data set, such as when target classes overlap.

5. Decision tree (DT): The non-parametric supervised learning technique known as the decision tree is widely used. The classification and regression tasks are both handled by DT learning techniques. DT categorises the instances by arranging the tree from the root to a few leaf nodes. Starting at the root node of the tree, instances are categorised by examining the attribute defined by that node, progressing along the branch of the tree that corresponds to the attribute value. The most common criterion for splitting is "entropy" for information gain and "gini" for the Gini impurity.

6. Random forest (RF): The ensemble classification method known as a random forest classifier (Breiman, (2001) is widely applied in the fields of machine learning and data science. This technique uses parallel-ensembling which runs many decision tree classifiers simultaneously on various data set samples and uses majority voting or averages for the conclusion or ultimate outcome. As a result, it reduces the over-fitting issue and improves control and forecast accuracy (Banerjee *et al.,* 2018). Therefore, RF learning models with several decision trees often have higher accuracy than models with only one decision tree.

7. Stochastic Gradient Descent (SGD): The term "stochastic" relates to random probability, and stochastic gradient descent (SGD) is an iterative technique to optimise an objective function for appropriate smoothness qualities. In return for a reduced convergence rate and faster iterations, this lessens the computing strain, especially for high-dimensional optimization challenges. The slope of a function used to determine how much one mutable would change in response to the changes in another is known as the gradient.

Artificial Neural Network and Deep Learning. When it comes to machine learning strategies, deep learning belongs in the same family as representation learning, which is based on artificial neural networks (ANNs). To acquire knowledge from information, deep learning provides a computational structural design that combines numerous processing layers, including input, hidden, and output layers (Pedregosa *el al.,* 2011). In many situations, deep learning outperforms more conventional machine learning techniques, and this is especially true when it comes to learning from enormous datasets. Multi-layer Perceptron, Convolutional Neural Network (CNN), and Long Short-Term Memory (LSTM) Recurrent Neural Network (RNN) are the most widely used deep learning algorithms (Sarker, 2021). To do this, we implement Convolution Neural Networks (CNNs)into our systems. To classify images, CNN combines feature extraction and neural networks. Five distinct layers make up even the most basic convolutional neural network (CNN): the input layer, the convolution layer, the pooling layer, the fully connected layer, and an output layer is depicted in Fig. 2.

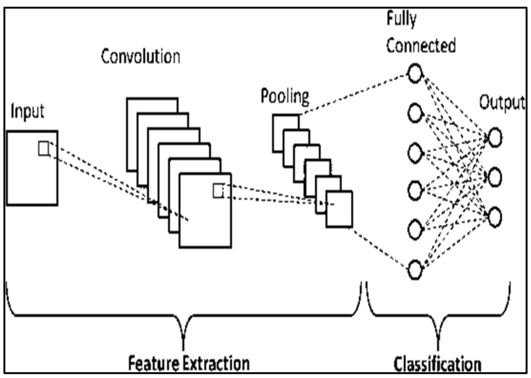

Fig. 2. Schematic diagram of basic CNN Architecture

C. Application of IoT and ML in Agriculture

In this section, some of the latest research work based on IoT and its concern technologies in the field of agriculture has emphasised. IoT devices play very significant role in improving agriculture products as smart systems.

1. Soil Nutrient Assessment and Monitoring: Soil is the foundation of agriculture. It gives crops the necessary nutrients they need to grow more quickly. The yield of a crop is significantly influenced by numerous chemical and physical aspects of the soil, including its moisture content, temperature, and pH level. The temperature, humidity, pH, and wetness of the soil are all monitored using an IoT sensor-based system that was proposed by Bhatnagar and Chandra (2020). Android smartphones were used to implement the system. There were three sensors used: DHT11, SEN: 0161, and SEN: 0193 for soil temperature, pH, and moisture, respectively. For the three types of soil in Rajasthan—loam, sand, and clay—a pH sensor and a soil moisture sensor were calibrated. The suggested system parameters were evaluated by accredited laboratories and validated using a t-test, and it was discovered that there was no statistically significant difference between calibrated values and values obtained from accredited laboratories. For farmers, agriculture scientists, chemists, agriculture professionals, and IoT experts, the proposed solution is advantageous. In Fig. 3, we can see an IoT-Based Soil Health Monitoring and Recommendation System.

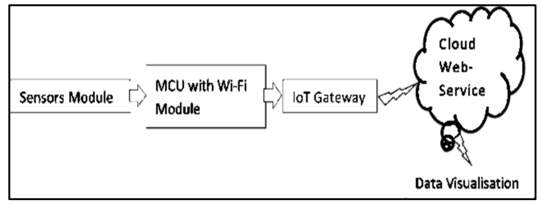

Fig. 3. IoT-Based Soil Health Monitoring & Recommendation System.

2. RGB Color Sensor Detection: A significant portion of any nation's gross domestic product (GDP) comes from the agricultural sector. Risk factors including the state of the economy, unfavourable weather patterns, human resources, and labour costs are what prevent the agriculture sector from expanding. A portable, real-time, cloud computing (Sowmiya *et al.,* 2019) framework employing NodeMCU and Arduino for soil nutrients such as temperature, humidity, soil moisture, and RGB colour values detection was proposed by Patil *et al.* (2021) to increase production. A soil doctor plus kit and an RGB colour sensor were used to analyse soil samples taken from diverse farms close to Pune, India. With the help of this suggested framework, farmers can easily access real-time soil metrics (temperature, humidity, soil moisture, and NPK & pH status corresponding to RGB values).

3. Soil-based Crop selection and Fertilizer management system: These days, estimating crops based on the soil is crucial for enhancing yield. A methodology and a standardised technique were established by Chellaswamy *et al.* (2020) to characterise the composition of bare soil, metalloids, and mesological parameters. A variety of sensors, including temperature, humidity, and video sensors, were employed to manage and keep an eye on the farm area. The region surrounding Tanjavur, Tamil Nadu, has taken into consideration for this study's crop selection for that region. A controller, GSM, and water level sensors are used to regulate irrigation. An application programme (APP) has created to find the best crop for an agricultural area, and it is simple to install on the farmer's smartphone. The findings showed that using fertilisers properly protects agricultural fields and boosts productivity. A test configuration for an experiment was created and put to the test in various scenarios.

4. Potential of wireless sensors and IoT: In the article, Ayaz *et al.* (2019) discussed the potential of wireless sensors and IoT in agriculture as well as the difficulties that will likely be encountered when combining such technology with conventional agricultural methods. A thorough analysis of IoT devices and communication channels linked to wireless sensors used in agriculture segment has conducted. The list contained sensors for a range of agricultural uses, such as crop condition, irrigation, insect and pest detection, and soil formulation. It has been described how technology aids agricultural growers at all stages, including planting, harvesting, packing, and transportation. The article also considered the usage of unmanned aerial vehicles for crop surveillance and other advantageous applications, such maximising crop output. Modern IoT-based technologies and architecture utilised in agriculture are also emphasised when appropriate. The authors have recognised present and future IoT in agriculture trends and highlighted prospective research problems based on this in-depth review. All of this led to the conclusion that every square foot of farmland was essential to maximising crop yield. Fig. 4 below depicts the main obstacles in sustainable agriculture in the future.

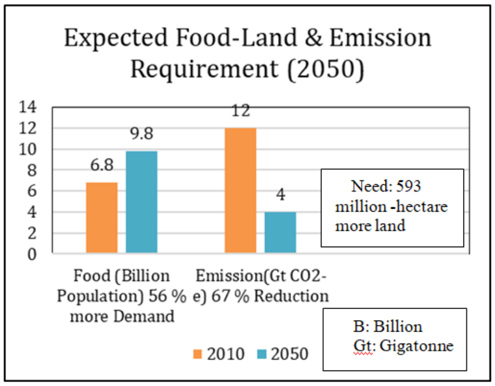

Fig. 4. Major Challenges for sustainable future agriculture.

5. IoT Framework for Measurement and Precision Agriculture: IoT architecture enables us to generate data for large and remote agriculture areas, and the same may be used for Crop predictions using machine learning methods, as described in the Bakthavatchalam *et al.* (2022) article. The N, P, K, pH, temperature, relative humidity, and rainfall are the factors that determine which crops are suitable in this situation.

According to Talaviya *et al.* (2020), unmanned aerial vehicles (drones) and sensor networks can assist bring about a revolution in agriculture by implementing AI for irrigation, weeding, and fertilising. The results have shown that production and quality have both increased. This article also includes a survey report from multiple researchers outlining contemporary trends in farm automation employing drones for spraying and monitoring.

Comparative Analysis. The one of the major goals of this comparative study is to identify any nutrient shortages in the soil by proper soil-testing, which is crucial for increasing the yield of different crops like wheat and soybeans. When soil is not properly treated, it begins to degrade. This degradation can be stopped by properly monitoring and controlling soil nutrients and pH levels utilising a variety of effective sensors and cutting-edge technology, as discussed above in section 2. Table 1has given a comparative analysis on the different technologies and protocols utilised in the field of precision agriculture to achieve this objective.

Contrarily, it is crucial to gather and analyse real-time crop picture data using machine learning algorithms to forecast and ensure plant diseases in place of optimal dosage of fertilisers and pesticides for the improvement of crop production and quality. As was said above in Section 3, different machine learning algorithms including machine vision and other AI techniques can be utilised in finding crop diseases at early stage of plant growth as shown in comparative analysis Table 2 for precision farming to increase crop productivity.

Table 1: Comparative analysis on IoT based framework and protocols used to find soil nutrient deficiency in various geographical areas.

Ref. No. Items	**Bhatnagar and Chandra (2020)**	**Patil *et al.* (2021)**	**Chellaswamy *et al.* (2020)**	**Kaelbling *el al.* (1996)**
Parameters	Soil moisture, Temperature, Humidity, pH	Soil moisture, Temperature, Humidity, pH	Temperature, Humidity	Soil moisture, Temperature, Humidity, Co_2
Processor/Control Mechanism	Arduino Uno Board with Atmel AVR Microcontroller	Node MCU with Arduino Board	Arduino Uno Board with Atmel AVR Microcontroller	Programmable logic controller
Protocol/Framework	Zigbee, IoT	TCP/IP, ESP8266 Wi-Fi	GSM, MATLAB	Zigbee, Bluetooth, Lora, Sigfox
Area of Study	Soil of Jaipur, Rajasthan	Soil of Pune, Maharashtra	Soil of Tanjavur, Tamilnadu	Not Specified
Advantages	The proposed system is beneficial for farmers, agriculture scientist, chemists, agriculture professionals and IoT experts.	The proposed method can communicate all real time soil parameters such as pH, Nutrients, temperature values anywhere in the world.	The algorithm developed for the soil-test based crop selection method estimates different parameters of the field based on the received data from the field sensors.	The potential of IoT and wireless sensors in agriculture field, along with the challenges projected to be faced when integrating that technology with the traditional farming practices.
Research Possibilities	This work can be extended with more geographical area and incorporation of other properties of soil, such as electrical conductivity and NPK present in the soil.	The proposed system provides NPK values proportional to RGB observed values and can be enhanced by using sensors with high accuracy.	Proposed system can be extended by incorporating more crops with other algorithms having higher accuracy and monitoring the field once in a day using a digital camera.	In farming, machine learning can be used to predict which genes are best suited for crop production and which products are of high demand or currently unavailable in the market.

Based on comparison done in Table 1, it is proposed that by proper soil testing and using IoT based framework & efficient machine learning algorithms, soil fertility status can be determined to find nutrient deficiency to achieve higher yield and quality. The outcome of this work is expected to help the farmers to manage the soil nutrient deficiencies by adopting proper dose of fertilisers and to make the sufficient stock of NPK & other fertilizers for future crops.

Table 2: Comparative analysis on machine learning and AI techniques to detect crop plant diseases.

Ref. No. Items	Phung and Rhee (2019)	Suchithra and Maya (2020)	Pedregosa *et al.* (2011)
Parameters	Kernel (3 × 3), Stride (2x2), Filter (32), Dropout (0.25)	OC, P, K, B, and pH	Potassium Fertility Status of Indian Soils
Processor/Control Mechanism	CNN: Convolution, Relu, MaxPool, FC, SoftMax	Activation functions: gaussian radial basis, sine-squared, hyperbolic tangent, and hard limit.	National Soil Health Card Database
Protocol/Framework	TensorFlow with Keras	Extreme learning machine Algorithm	The Soil Health Card & Soil Health Management under National Mission for Sustainable Agriculture
Area of Study	Singapore	Kerala	India
Advantages	The central problem of small datasets is overfitting, for which we applied two regularization techniques (L2 weight regularization and data augmentation) to avoid overfitting and to increase generalization of the model.	Improvement in the accuracy rate of fertility indices of soil nutrients and soil pH level in Kerala using ELM methods.	The Indian soils are not always rich in potassium, and that the balanced fertiliser application needs to be followed.
Research Possibilities	The proposed model can be applied on different datasets and accuracy can further be improved by using some other algorithms.	Widespread deficiency of secondary and micro-nutrients is observed, advanced neural network techniques can be used for fertilizer recommendation.	This work can be extended with coverage of more geographical area and consideration of other soil nutrients required for the crop.

Based on comparison done in Table 2, it is proposed that by using efficient deep learning algorithms including computer vision, plant diseases can be determined at an early stage to protect crops & achieve higher yield and quality. The outcome of this work is expected to help the farmers for their financial growth by determining plant diseases at early stages for better prevention and cure.

Proposed IoT enabled Framework. As per the analysis to fulfil the future food requirement around 56% more food production is needed by 2050. The finding of deficiencies of soil nutrients at macro and micro levels for increasing the productivity by the selection of suitable crops and recommendation of fertilizers. The detection of plant diseases at early stage using emerging IoT enabled technologies, machine learning algorithms and AI techniques provide guidelines to the farmers to use proper and timely dose of pesticides and herbicides also. The proposed IoT enabled framework shown below in Fig. 5.

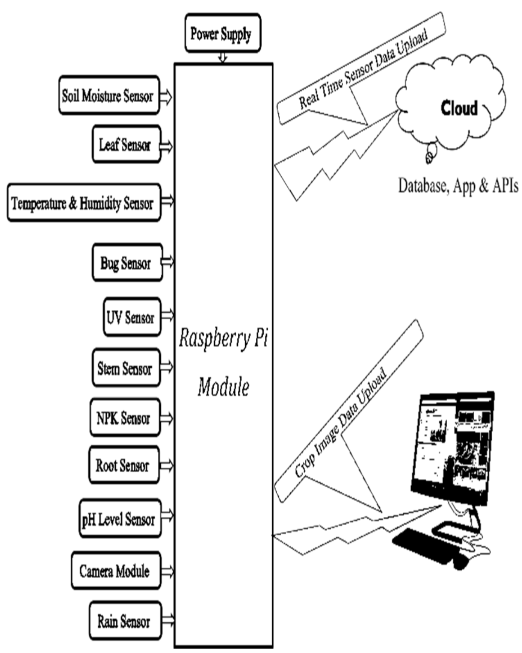

Fig. 5. IoT enabled Framework to regulate Soil & Crop health.

Soil Test Result & Fertilizers Recommendation. Soil is a major source of nutrients required for plant growth. The primary essential soil nutrients: Carbon, Hydrogen, Nitrogen, Oxygen, Phosphorous and Potassium are required in large mount while secondary nutrients: Calcium, Magnesium and Sulphur needed in moderate amount for healthy crop plant growth. Table 3 provides a comparative analysis based on the dataset (2019-20) available at the government portal and the actual soil test laboratory results taken from Krishi Vigyan Kendra, Kasturbagram, Indore (M.P.) and fertilizers recommendations (Dupare and Billore 2021) required for the growth of soybean and wheat crops respectively.

Table 3: Comparative Analysis on soil test results and fertiliser recommendation.

Sr. No.	Soil Parameters	Nutrient Level (District-Dewas, M.P.)				Normal Value recommended by soil test lab	Fertilizer Recommendation @	
		Field 1		Field 2			Soybean	Wheat
		Survey No 105		Survey No (33/298)				
		Village-Tinoniya		Village-Molay				
		2019*	2022#	2019	2022			
1	Soil pH	7.30	7.32	6.90	7.83	6.0 - 8.5		
2	EC (dS/m)	0.43	0.56	0.62	0.45	< 1		
3.	Organic Carbon (%)	0.96	0.61	0.49	0.58	0.50 - 0.75		
4	Nitrogen (Kg/ha)	225	214	198	203	250 – 400	25	120
5.	Phosphorus (Kg/ha)	20.88	12.52	21.03	13.62	10 – 20	60	60
6.	Potassium (Kg/ha)	364	316	407.40	366	250-400	40	40

* Govt. portal Dataset(2019-20), #Soil test lab result.
@ Dupare and Billore (2021).
Note: Mixed DAP Fertilizer Composition: 18% N_2 and 46% P_2O_5
Mixed NPK (12:32:16) Composition: 12% N_2, 32% P_2O_5, 16% K_2O (Water Soluble Potash).

CONCLUTIONS

Recent findings suggests that agriculture is a very significant sector for Indian economy, contributing about 17% to the total GDP and offering employment to over 60% of the population. Therefore, it is indeed to reform farming by timely soil testing & crop disease detection using machine learning algorithms and AI techniques efficiently on real time datasets via computer vision to get soil fertility and crop health status regularly. This paper provides the detailed analysis to find both soil nutrient deficiencies and crop ailments to ensure proper dose of fertilisers and make available the sufficient stock of NPK & other fertilizers for future crops for achieving higher yield and quality respectively. The proposed IoT enabled Framework along with soil test result helps the farmers to regulate Soil and Crop Health for their financial growth through proper selection of crop and determining plant diseases at early stages for better prevention and cure.

FUTURE SCOPE

We are planning to develop the proposed IoT enabled Framework to regulate Soil & Crop health for the betterment of crop quality and production both so that farmers become financially strong and contribute to enhance nation economy.

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Conflict of Interest. None.

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