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IoT-based Recommender Engine for Yielding Better Crops

Aaditya Aggarwal, Durgansh Sharma

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Abstract

Background: Artificial Intelligence (AI) operations have evolved over the last two decades in improvising the operations for an agriculture-based economy. The operations in this area face many challenges in maximizing their crop yield while facing the challenges like deficient soil treatment, problems from pests and crop-based diseases. Technical challenges for the requirements of real-time data which can be further transformed to big data. Its impact is fetching low yield, because of the knowledge gap between farmers and technology. These points are the key motivators of introducing an ecosystem with artificial intelligence to agriculture in this research work. IoT devices are capable to generate large amounts of data that could be transformed into information about environmental parameters like the temperature of the field, which acts as an engine to provide data. All the data shall be collected, stored and further analyzed for better decision-making. One way the business uses the data collected is by nourishing it into the AI systems, which grasp the IoT data and further use it to make predictions.

Methods: This research work enables to cater the solution for supporting the farmers with IT as an enabler using data analytics on the collected information. It uses a web application that would help to monitor the soil fertility and suggest the producers to select the best crop(s) that can be grown in that geographical region.

Result: The result from our crop recommender engine successfully predicted which crop(s) we could choose to grow in our gardens or farm fields. An extensive soil study along with meteorological models helped us to launch a smart agricultural system in a much smarter way. This has further helped to bridge the gap between production and quantity yield.

Key words: Agriculture, Artificial intelligence, Big data analytics, Crop management, IoT, Mobile framework, Smart farming, Soil management, Web application.

Introduction

Agriculture is India's primary source of income. 70 per cent of Indian households in rural villages depend on agriculture as their main source of income. The small and marginal farmers account for 82 per cent of all farmers in India. India has a wide range of agricultural and ecological diversity. The Himalayas lie to the north, the Thar Desert to the west, the Ganges Delta to the east and the Deccan Plateau to the south. India is the largest producer of milk, pulses and jute in the world. It also ranks second in the world in the production of cotton, vegetables, rice, groundnuts, wheat, fruits and sugar.

The climatic conditions in India range from the wet and dry tropics in the south to the temperate Alps in the north. It has a wide range of ecosystems. The Indian subcontinent is home to four of the world's 34 biodiversity hotspots and 15 of the World Wildlife Fund's 200 eco-regions (FAO in India, 2021). Agricultural practices in India face many challenges, such as changing climatic conditions, different geographical environments, conventional agricultural practices and economic and political patterns. Economic loss due to a lack of knowledge about crop productivity is another crucial concern in the country. These obstacles can be overcome by implementing advanced technologies in agriculture.

Smart farming focuses on the management of agricultural activities utilizing data received from multiple sources. It doesn't mean it's a smart system just because it's based on technology. The ability to record and understand data distinguishes intelligent systems. Smart Farming collects data and provides information that may be used to manage all of the company's operations, both before and after the harvest, using technology and software. The information is well-organized and always available. IoT in agriculture relates to sensors, drones and robots that are connected to the network and operate immediately or semi-automatically during processes and data collection. Its goal is to improve efficiency and predictability. Semi arm-mounted robots can detect weeds and spray pesticides on damaged crops which helps to save crop and pesticide costs. These robots are also capable of picking up and lifting objects. Even heavy agricultural vehicles can be driven from the comfort of your home using cell phone screens to complete their duties and their position can be tracked at any time *via* GPS. Drones with sensors and cameras are used to take pictures, map and monitor farms. The data collected can be used to improve

School of Business and Management, Christ University, Delhi NCR, Ghaziabad-201 003, Uttar Pradesh, India.

Corresponding Author: Aaditya Aggarwal, School of Business and Management, Christ University, Delhi NCR, Ghaziabad-201 003, Uttar Pradesh, India. Email: aaditya1.aggarwal@gmail.com

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crop health, irrigation, spraying, soil and field management, crop counting and yield prediction (Smart Farming).

IoT-based remote sensing collects data from sensors near farms such as weather stations and sends them to an analysis tool for verification. They keep track of how the plant's sunlight, humidity, temperature, shape and size can change. The data collected by the sensors for humidity, temperature, humidity, precipitation and dew detection aid in predicting weather conditions on farms so that the appropriate crops can be grown. The study of soil quality determines the nutritional value and the driest parts of the farms, as well as the drainage capacity or acidity of the soil, allowing the farmer to change the amount of water required for irrigation and choose the best lucrative crop. Computerized imaging involves installing cameras with sensors throughout the farm or using drones.

Literature review

Precision agriculture is the most common application of the IoT in agriculture. It makes farming practices more precise and well-planned by including processes such as real-time monitoring of crop and soil conditions, plant health monitoring and weather forecasting. Farmers can manage their fields based on the knowledge gained through this system. With the use of mobile devices, high-speed internet and durable, low-cost satellites for imaging and positioning, the IoT-embedded AI system can provide alerts and up-to-date data to optimize crop growth processes and reduce crop loss because of pests, harmful soil moisture, or atmospheric damage. IoT-equipped irrigation systems not only conserve water but also ensure that crops receive the proper amount of water for optimal growth. This method of irrigation is based on the moisture level of the soil rather than irrigation based on predetermined intervals.

Mr. Sankha Subhra Debnath offered "Implementation of IoT to study different soils for efficient irrigation" and showed the mechanism of irrigation which can control the pump motor according to dryness and humidity of the ground. The sensors used along with the microcontr oller shape heart of the smart devices. ESP8266 was also used to connect the system to an IoT platform. Sensors then collected real-time data over time which allowed the user's to examine the soil used in the irrigation system. This further resulted in more optimal water management (Sankha Subhra Debnath, 2020).

Mrs. S Nalini Durga presented "Soil Moisture Based Smart Irrigation System Using IoT". The document shows the monitoring and controlling of irrigation with the help of IoT. The system was created to manage production with environmental conditions. This includes temperature, soil moisture content, air humidity and water level for irrigation control. The real-time data collected was then transmitted to the cloud server for future storage, decision-making and action control (Nalini and Durga, 2018).

Mr. Chetana and Kestikar proposed "The Wireless Automated Irrigation System" which is an easy-to-use system that notifies the user of its status. The system has two operating modes that allow the user to choose between automatic and manual processing. The system is capable of providing a log file of the events that have occurred. By selecting the manual operation mode, the system will function as the traditional irrigation system. The user decides when to start irrigation and when to stop it. When the automatic operation mode is selected, the user does not have to pay attention to shutting down the system after it has started. Irrigation will be decided based on the humidity level values (Chetana and Kestikar, 2012).

Mr. Kalpataru B. Patil and his team proposed an "Agriculture Environment Monitoring System using Android Wi-Fi". The document demonstrated how cloud computing devices can be used to build a complete computer system. The research includes sensors and instruments that can monitor data from the images collected in agricultural fields. This concept proposes a new methodology for smart agriculture by using wireless communication technology to connect the smart sensing system with the smart irrigation system (Kalpataru and Patil, 2018).

All of the above-mentioned systems are linked to the WSNS node. The distinction is based on the techniques used and the information obtained from the nodes. The collected data is usually stored on one or more servers. As the number of nodes grows, servers will require more storage space, resulting in a cost increase.

Smart agriculture ecosystem

The smart agricultural ecosystem as shown in Fig 1 is a rapidly expanding cyber-physical sector that is gaining widespread acceptability in agriculture-dependent economies. When it comes to precision agriculture, the notion entails placing sensor devices across agricultural land to improve farming practices while using as few human and natural resources as possible. These sensors assist farmers to make the best decisions for their crops by providing data-driven applications. Smart sensors can aid in crop damage reduction. The GPS sensors on the farm collect latitude, longitude, altitude and environmental data for crop mapping. Sensors that measure humidity and temperature can help detect germination issues or the danger of overwatering the fields. The data obtained by these embedded sensors results in smart manufacturing by reducing the overuse of fertilizers and water on farmlands (Sai Sree Laya Chukkapalli, 2020). Feng Yang recommended a cloud-based framework where big data collected by the farm's sensors can be stored in the cloud for faster calculations, which helps to make decisions smoothly (Feng Yang, 2018).

Soil management

Soil management is an essential component of all agricultural-related activities. A clear understanding of the different soil types and environmental conditions can increase production and preserve soil resources. Management alone implies the application of operations, policies, procedures and treatments that can help to improve soil characteristics. A typical soil survey approach can detect pollutants in urban soils. The enhanced aggregation suggests the presence of organic elements, which are vital in preventing the formation of the soil crust formation (Ngozi Clara, 2019).

Crop management

Crop management typically starts with the planting of the crops and progresses through crop growth, harvest, storage and distribution. It is defined as activities that increase agricultural productivity, growth and output. The growth of crops is based on their timing and the type of soil in which they prosper. Precision Crop Management (PCM) is an agro-based based management system that allows to assist crops and soil inputs based on geological needs in order to maximize profitability while protecting the environment (Ngozi Clara, 2019).

Farmers must employ a variety of crop management strategies to deal with the arising soil water deficit, climatic conditions, or limited irrigation. When deciding between crops, the drought's timings, intensity and predictability are all important factors to consider. A deep understanding of weather patterns can help with high-quality decision-making, which can lead to high-quality crop yields. The crop prediction method can predict the appropriate crop by detecting various soil parameters and atmospheric parameters. Some of the factors that must be considered are soil type, pH, nitrogen, phosphate, potassium, organic carbon, calcium, magnesium, sulphur, manganese, copper, iron, depth, temperature, precipitation and humidity.

Materials and Methods

This study describes the use of agricultural raw data collected over a period of time by the Indian Chamber of Food and Agriculture. This dataset is then pre-processed and analyzed at Christ University, Delhi NCR, Ghaziabad, India. Initially, the dataset used by us in this study contains parameters such as the soil nitrogen, phosphorus and potassium content ratio, the temperature in degrees Celsius, relative humidity in percentage, the soil pH value, the name of the crops, *etc*. The dataset's parameters greatly helped in the creation of the IoT-based crop recommender engine, which is now available on the created webpage.

Proposed problem

Agriculture has been practiced for thousands of years, even though it has been underdeveloped for a long period. To meet our demands after independence, we imported grain from other countries. However, during the green revolution, we became self-sufficient and began exporting our excess to other nations. To raise grains, we used to be fully reliant on the monsoons, but now we have dams, canals, tube wells and pumps. Furthermore, we now have a wider range of fertilizers, insecticides and seeds, allowing us to grow more grain than previously. Agriculture's specialized expertise has improved as technology and innovative equipment have progressed. In today's world, it is difficult to predict which crops we can choose to grow in our gardens or farm fields as it requires a lot of time and human effort.

An extensive soil study, along with meteorological models, can help us launch a smart agricultural system in a much smarter way.

Proposed system

In the proposed system as illustrated in Fig 2, crop monitoring is carried out with the help of the various sensors which are used to collect information from the agricultural field. These sensors are further integrated into devices that are used as tools in agricultural fields. To check for the nutrients, present in the soil, a person or a farmer can use a soil NPK meter and to check the pH value of the soil, he or she can use a soil pH meter. The information collected from these sensors can be viewed on the LCD screen of these smart devices. In addition to this, climatic conditions such as atmospheric temperature and humidity can be viewed from the created web page.

After collecting all the information, the crop recommender engine which is available on the webpage can be run and all the fields can be filled according to the asked conditions to get the name of the recommended crop(s).

Results and Discussion

Implementation

The implementation of the proposed model needs all the information to share through the crop recommender engine. This information retrieval process initiates through our website currently and later we shall associate it with our

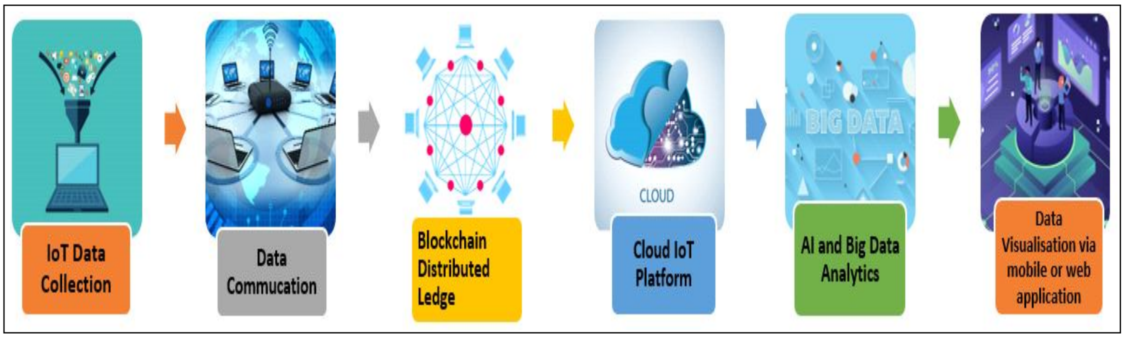
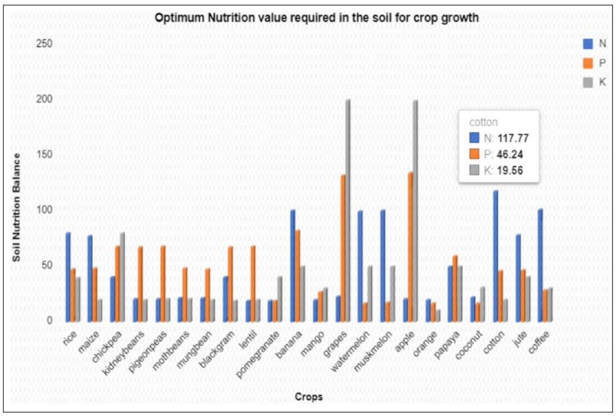


Fig 1: Illustration of smart agriculture ecosystem.

upcoming mobile app as well. It leads the searcher to reach our recommender web page through which the person can enter the data provided by the smart devices (later this process shall get automated through process automation). Once the reader initiates the search process, it triggers the parameterized query and provides the sorted prioritized search results as mentioned in stage 4 of Fig 3.



Graph 1: shows the representation of the optimum nutrition value of the soil nutrients which are required to grow the crops.

Infographics

1. Bar graph showing the representation of optimum nutrition value of the soil nutrients which are required to grow the crops.

Graph 1, above demonstrates the optimum nutrition value in the soil for growing a specific crop. As for the growth of cotton the optimum value nutrition present in the soil should be:

- Nitrogen (N): 117.77
- Phosphorus (P): 46.24
- Potassium (K): 19.56

2. Bar graph showing the representation of optimum weather conditions in which the different crops can be grown.

Graph 2, above demonstrates the optimum weather condition to grow different crops. Like for example to grow rice the optimum weather condition:

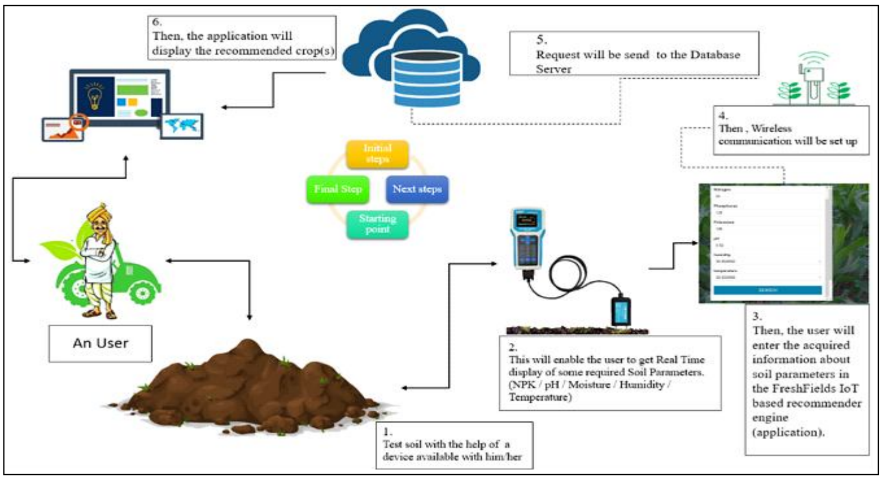


Fig 2: Illustration of crop monitoring system.

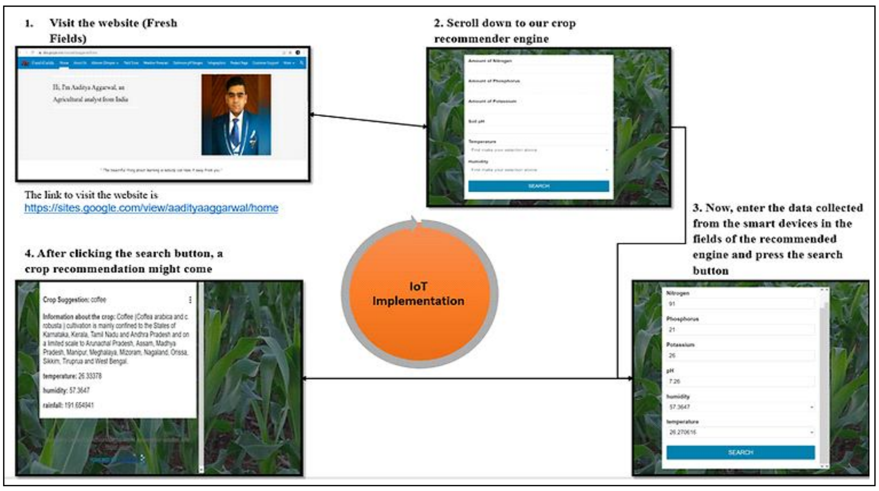
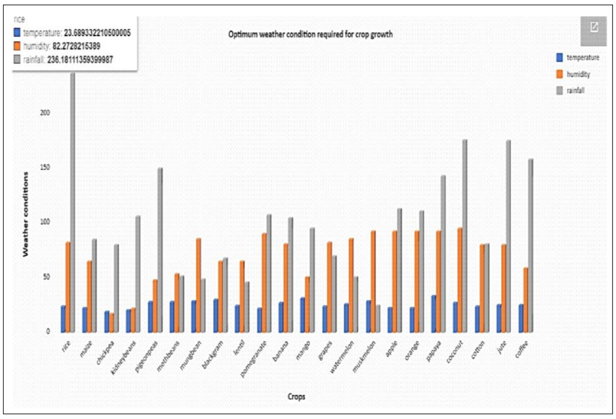


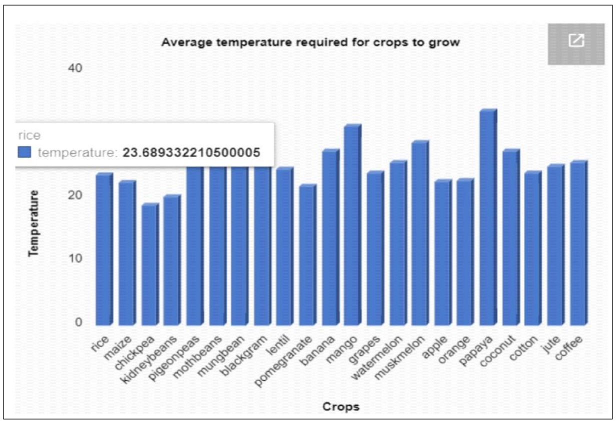
Fig 3: IoT implementation of the model.

- Temperature: 23.68
- Humidity: 82.27
- Rainfall: 236.18

3. Bar graph showing the representation of the average temperature in which the different crops can be grown.



Graph 2: Shows the representation of optimum weather conditions in which the different crops can be grown.



Graph 3: Shows the representation of the average temperature in which the different crops can be grown.

Graph 3, above demonstrates the optimum Temperature to grow different crops. Like for example to grow rice, the optimum temperature should be around: 23.68.

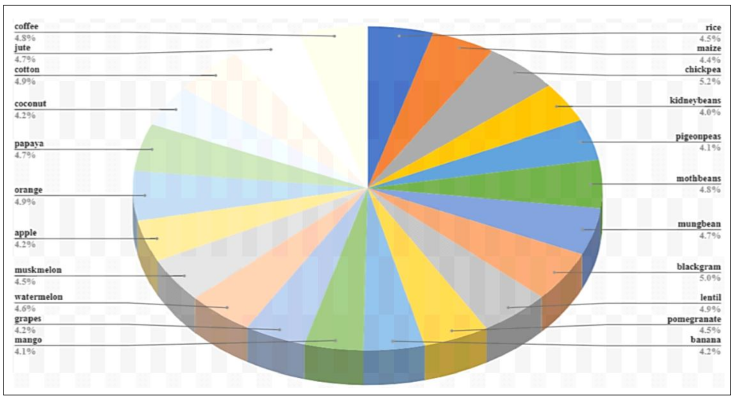
4. Pie chart showing the representation of optimum pH condition of the soil in which the different crops can be grown Graph 4, demonstrates the optimum pH required for crop growth. In the case of rice, it is 4.7%.

Soil pH is frequently used to determine the acidity (sourness) or alkalinity (sweetness) of the soil. The pH of the soil is expressed using a simple numerical scale. The scale ranges from 0.0 to 14.0, with 0.0 representing the most acidic and 14.0 representing the most alkaline. The value of 7.0 is neutral, indicating that it is neither acidic nor alkaline. (University of Vermont Extension).

The future of farming in India

Agriculture in India provides a living for the bulk of the population and should never be overlooked. Agricultural output has increased even though its proportion to GDP has decreased to less than 20%, while other sectors' contributions have increased at a higher rate. This has enabled us to become self-sufficient and transformed us from a food basket after independence to a net exporter of agricultural and allied products (Sharma, 2021). The agricultural sector provides a living to around 58% of the Indian population. Every year, India's food sector aims to expand and contribute more to the global food trade. India has the world's sixth-largest food and grocery markets, with retail accounting for 70% of total sales. India's food sector is one of the country's largest industries, accounting for 32 percent of the country's total food market. In terms of production, consumption, exports and expected growth, it is ranked 5th. In FY21, total exports of agricultural and related products were $41.25 billion (India 2021).

In fiscal 2020, agriculture, forestry and fisheries are expected to have a gross added value of Rs. 19.48 lakh crore. In fiscal 2020, agriculture and related sectors contributed 17.8% of India's gross value added (GVA) at current prices. After a contraction due to the pandemic, consumer expenditure in India would expand again in 2021,



Graph 4: Shows the representation of the optimum pH condition of the soil in which the different crops can be grown.

with a 6.6 per cent increase (India 2021). According to the second advance projections for 2019-20, total food grain output in the country would reach a new high of 291.95 million tonnes. This is good news, but the Indian Council for Agricultural Research (ICAR) predicts that demand for food grain will climb to 345 million tonnes by 2030. Increased demand for quantity, quality and healthy food, as well as a variety of foods, would result from India's growing population, rising average income and globalization effects. As a result, the pressure to produce more quantity, variety and quality of food will continue to grow as available cultivable land decreases.

CONCLUSION

So we can conclude that agriculture's future is a critical issue for planners and all other stakeholders. Amid the drop of market intermediaries, the government and other sectors of India are trying to address the main concerns in Indian agriculture such as increasing the income for the small farmers, increasing the number of primary and secondary processing units and developing a new and efficient supply chain model. Further, building a strong infrastructure will enable effective resource enumeration and marketing. It's indeed necessary to concentrate on cost-effective technologies that also safeguard the environment and conserve our natural resources.

In this paper, we have proposed a method for efficient crop monitoring in the agricultural field. With IoT applications, data can be stored and retrieved from anywhere. IoT is about the power of data. Our world is digitally connected and data is a fundamental resource. The data from the smart devices can guide the farmer in making decisions. Data can help them to grow crops smarter and safely and further, help them to adapt to the fast-changing environment. Despite these facts, the average productivity of many Indian crops is extremely poor. The country's population is predicted to grow to be the next world's largest in the coming decade and feeding them will be a major concern. Farmers are still unable to make a decent living.

Conflict of interest: None.

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