IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⋇ Peer-reviewed & Refereed journal ⋇ Vol. 11, Issue 6, June 2024

DOI: 10.17148/IARJSET.2024.11609

Prediction of crop yield using Machine Learning with integrated IoT

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Abstract: One major economic force is agriculture. A healthy biosphere depends on it. Almost every area of human life is dependent on a variety of agricultural products. The needs for more food of a higher caliber are growing, and farmers must adapt to these changes. In order to increase yield in order to help with the decision of planting the appropriate crop under certain circumstances, farmers must be informed of the climatic conditions. By continuously monitoring the field, IoT-based smart farming enhances the agricultural system as a whole. It provides an extremely clear real-time observation while monitoring a number of variables, including temperature, humidity, soil, and so forth. Machine learning in agriculture is used to improve the productivity and quality of the crops in the agriculture sector. Use of appropriate algorithms on the sensed data can help in recommendation of suitable crop.

Keywords: Include at least 4 keywords or phrases.

I. INTRODUCTION

Agriculture is the main economic sector in India.Indian agriculture sector accounts for 18 percent of India's GDP and provides employment to 50% of the country's workforce. But latest studies have shown a steady decline in the contribution made by agriculture to the Indian economy although it is demographically the broadest economic sector and plays a significant role in the overall socio-economic fabric of India. In order to identify a pattern, the procedure involves analyzing, predicting, and extracting significant information from massive amounts of data. Businesses utilize this procedure to transform their customers' raw data into insightful knowledge. Agriculture is another industry that can benefit from this approach. The majority of farmers based their expectations for a larger crop yield in the following harvest season on their extensive field experience, yet they still don't receive the crop's fair price.

This is primarily caused by inadequate irrigation, poor crop choices, or, on occasion, lower-than-expected crop yields.The need for an effective system to forecast and enhance crop growth and yield is voiced by agricultural researchers. Biological mechanisms are the main focus of agricultural research efforts to better understand crop growth and output. Crops are influenced by various elements such as the kind of crop, seed type, and environmental conditions like temperature, soil pH, humidity, and sunlight. By determining which crops will provide the maximum yields, one can estimate the net crop yield by studying the soil and atmosphere in a particular area. For the farmers, this forecast is helpful. Based on the kind of soil, temperature, humidity, water level, spacing depth, soil PH, season, fertilizer, and months, to select crops that are suitable for their farm. Since crop output is influenced by a wide range of variables, including soil, weather, crop cultivar genetic potential, irrigation and fertilizer usage, and biotic stress, estimating crop yield is a challenging process.

Many techniques have been developed for estimating agricultural yields, including statistical, agro-meteorological, empirical, biophysical, and mechanistic approaches. Information transfer from traditional farmers to knowledgeable farmers is known as "smart agriculture." Considering a variety of technological elements and a recently constructed weather index as inputs, the goal is to estimate the aggregate physical production functions for the yields of different crops in specified states. The analysis of rice production based on available data was conducted using regression and coefficient of determination analysis, along with average error rate, to create a fair comparison between our actual result, which we call the target, and prediction model. This user-friendly interface provides farmers with information about rice production.To maximize crop productivity, various data mining approaches were employed to estimate crop yield. For operational programs, precise and timely monitoring of agricultural crop conditions and estimation of potential crop yields are crucial procedures. This study's goal is to use a variety of forecasting techniques to assess agricultural yield estimations in Ghana due to the significance of crop yield prediction. projecting crop yields, which gives decision-makers information.

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Numerous climatic factors influence agricultural productivity. Such as soil parameters (PH, organic carbon, phosphorus, fiber, etc.), precipitation parameters (rainfall, region-specific rainfall, irrigation, etc.), and metrological parameters (humidity, wind speed, temperature, and moisture). Everything is messed up as a result of the constant changes in climate conditions.Farmers in India continue to use the customs and methods that their ancestors taught them. The only issue is that, back then, everything happened on schedule and the climate was really healthy. However, as a result of global warming and numerous other circumstances, most things have now changed. India's primary agricultural issue is a deficiency of seasonal rainfall. We must create a system that can uncover buried data, patterns, and insights in order to solve the aforementioned problems. In order to maximize his or her own profit, the farmer can forecast which crop to plant. We are using data analytics techniques in the proposed system to analyze agriculture production-based datasets and extract insights that would aid farmers in making decisions. The suggested methodology for crop yield prediction is provided in this section.

Crop yield prediction is done to estimate production in the agricultural sector so that better crop management decisions can be made, and so that future crop yield can be improved. The current model can be integrated with a decision support system (DSS) for precision agriculture, which intends to run the farm entirely. Climate, market location, crop area, and other factors are not taken into account.The system ignores the sowing date and the amount of land under cultivation. There is no consideration of the harvested crops' market value. This section presents the suggested techniques for estimating agricultural yield. By estimating production in the agricultural sector, crop yield prediction is a useful tool for planning future crop management and increasing crop yield. The existing model can be linked with a decision support system to achieve entire farm management and be used in precision agriculture.

Use the Naive Bayesian algorithm to predict crop yield accurately and recommend the appropriate amount of fertilizer to achieve the desired crop yield. Using data mining techniques on historical crop output and climatic data, numerous predictions are produced that lead to higher crop productivity.Utilizing an Internet of Things device, forecast variables including sunlight (temperature), soil (pH), water (pH), NPK, rainfall, and humidity.

➢ Use machine learning to give the farmer the crop's yield based on the acreage of the field, the amount of rainfall, the temperature, and the district.
➢ Forecast the price of crops at the market by utilizing historical crop prices and anticipated yield information.
➢ To use random forest and multiple linear regression to forecast agricultural prices. Make recommendations on fertilizer application to improve crop productivity.
➢ Tell the farmer what the crop growth rate is in percentage terms.
➢ Use machine learning to give the farmer the crop's yield based on the acreage of the field, the amount of rainfall, the temperature, and the district.
➢ Forecast the price of crops at the market by utilizing historical crop prices and anticipated yield information.
➢ To use random forest and multiple linear regression to forecast the crop prices for eight crops and six significant districts.
➢ To evaluate the expected outcomes of various algorithms and identify the most appropriate method.via a mobile phone SMS format.

II. LITERATURE SURVEY

[1] For governments and other agricultural stakeholders, making the most of remote sensing technologies has become essential in the quest for precise rice crop forecast. The shortcomings of satellite remote sensing's spectral and spatial resolution still exist, despite its wide coverage. Hyperspectral sensor-equipped Unmanned Aerial Vehicles (UAVs) offer a viable alternative, nevertheless, as they can provide high temporal and spatial resolution as needed. This work presents the idea of relative vegetation indices and relative yield, which improve accuracy by allowing accurate pixel-level estimation. A strong model with an impressive R2 value of 0.74 and a low RMSE of 248.97 kg/ha is produced by utilizing hyperspectral pictures to analyze important growth stages of rice and identify the best combinations of vegetation indices.

[2] As the world's population continues to climb, ensuring sufficient agricultural output becomes more crucial for both economic growth and food security. Accurately monitoring crop growth and computing yields are crucial elements of national and international economies and food management strategies. Thanks to recent developments in deep learning, particularly in the field of image classification using Convolutional Neural Networks (CNNs), there has been a discernible change in the application of deep learning algorithms for crop monitoring and yield estimate. Long-Short Term Memory Networks (LSTMs) and Support Vector Machines (SVMs) are two examples of the classical machine learning techniques that are commonly used in traditional approaches, but they have also shown promise in this sector when it comes to deep neural network models.

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[3] India's economy depends heavily on agriculture. A useful technique for raising crop yields is data analysis. Anticipating output ahead of time has significant advantages for farmers. To do this, variables such as soil composition, location, weather data (from APIs), and soil nutrients (pH, NPK) can be taken into account. A model that predicts crop production and suggests the best fertilizer use under particular circumstances can be created by using machine learning to analyze this data. Farmers' earnings and crop yield can both be greatly increased by using this strategy.

[4] Agriculture is the principal source of livelihood for more than 40 percent of the population of this state. According to Food and Agricultural Organization (FAO)researchers, between 2010 and 2050 the world population will increase by one third. The demand for crop production will increase by 60% higher than the current production. Hence prediction plays a major role to find out the demand of crop production for maximizing the yield. For that in this paper we propose the prediction method for the major crops of Tamil Nadu using K-means and Modified K Nearest Neighbour (KNN). MATLAB and WEKA are used as the tool for clustering and classification respectively. The number result shows that our method is better than traditional data mining approach.

[5] This study focuses on utilizing machine learning to enhance the forecast of rice crop yield in India while taking climate factors into account. The rainfall, temperature, and crop evapotranspiration data from Maharashtra (1998–2002) are all analyzed in this study. They compare their use of a certain algorithm (SMO) to others. The findings indicate that alternative methods outperformed SMO on this dataset, despite SMO achieving respectable error rates. This implies that in order to optimize rice yield forecast in India, it is imperative to investigate various machine learning techniques.

[6] This research tackles predicting winter wheat maturity dates to optimize harvest schedules. Existing models often struggle with regional variations or limited prediction windows. Here, they propose a new framework that integrates satellite data (LAI) with a crop growth model (WOFOST) and weather forecasts. They test this approach in Henan Province, China, by calibrating WOFOST with field data and optimizing its parameters using a special algorithm (SCE-UA) based on satellite LAI measurements. This allows them to simulate wheat growth and predict maturity dates across the entire region for the next 16 days. The results show good accuracy (R^2=0.9) with minimal error (RMSE=1.93 days). This method offers a significant improvement over previous methods by considering regional variations and providing longer-term predictions.

[7] This paper presents the results of an experiment carried out to relate the yield from various crops to TerraSAR-X dual polarimetric imagery. X-band wavelength has higher sensitivity to smaller crop structures, especially stem and head density making it suitable for relating yield to backscatter. The coherent dual-polarimetric mode ofTerraSAR-X was also used to emphasize the volume scattering through dual-polarimetric entropy/alpha decomposition. Good correlations to yield data as gathered by harvester telemetry were obtained.

[8] Researchers investigated remote sensing indicators for crop growth monitoring at both canopy and regional dimensions in a study focused on winter wheat in Hebei province, North China Plain. In order to establish relationships between vegetation indices and Leaf Area Index (LAI) throughout several phenological stages, canopy spectra and LAI data were gathered and evaluated through field trials with varying fertilizer treatments. Notably, NDVI proved to be the best predictor during the heading and milk stages, while SAVI (L=0.2) was beneficial during the jointing stage. SAVI (L=0.3) demonstrated promise during early elongation. The study highlighted the significance of vegetation indices that might mitigate the effects of soil, especially in areas with varied crop coverage during the early growth phases, by utilizing multi-spectral remote sensing data from the HJ-IA satellite.

[9] The IPCC emphasizes that climate change poses a serious danger to agricultural production, particularly in areas like South Asia and Sub-Saharan Africa where data scarcity hinders research and development. Researchers looked at how agriculture and climate forecasts fit together through a thorough examination. They then conducted a three-step analysis that emphasized how important climate data is for determining how agriculture will be affected. Although agricultural researchers tend to favor field-scale weather data, this study highlights the potential benefits of combining weather generators with large-scale datasets. Sensitivity study demonstrated the vital significance of strong weather station networks, especially in high-altitude areas such as Ethiopia and Nepal where significant data loss affects temperature and precipitation estimations.

[10] In addition to acknowledging their vital significance in conjunction with other variables including weather, soil properties, and crop management techniques, this paper explores the complexities of regulating water and nitrogen in agriculture. It presents a thorough cropping systems simulation model called Crop Syst that includes elements related to crop growth, nitrogen, and water. Although the model provides an accurate description of crop water usage, projections about nitrogen in the soil profile show some discrepancies from actual values, even if they generally follow the trends. However, across a variety of crops and regions, the model shows encouraging concordance between simulated and actual biomass and yield, suggesting its potential as a useful tool for examining nitrogen and water management strategies.

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III. IMPLEMENTATION

The act of putting a plan, a method, or any other design, idea, model, specification, standard, or policy into effect is known as implementation. Therefore, in order for anything to happen, implementation is the course of action that needs to be taken after any initial thought. Users can assume control of an implementation for the purposes of use and assessment. It entails preparing for a seamless changeover and teaching users how to operate the system. Ensuring the information system is operational is the process of implementation. Creating a fresh system from the ground up. Creating a new system from the ground up.

Based on the ATmega328 seen in Figure 1, the Arduino Uno is a microcontroller board. The device is equipped with 14 digital input/output pins, six analog inputs, a ceramic resonator operating at 16 MHz, a USB port, a power jack, an ICSP header, and a reset button. Additionally, there is a reset button on the device. The microcontroller can be powered by an AC-to-DC adapter or battery, or it can be connected to a computer via a USB cable. All necessary components are included to support the microcontroller. Unlike all previous boards, the Uno does not make use of the FTDI USB-to-serial driver chip. Rather, it has the Atmega16U2 (or Atmega8U2 up to version R2) configured as a serial-to-USB converter.The shields can adjust to the voltage supplied by the board thanks to the additional SDA and SCL pins that are located close to the AREF pin and two more new pins that are placed close to the RESET pin and the IOREF. Protectors will eventually work with both the 3.3V Arduino Due and the 5V AVR-powered boards. A non-connected pin that is set aside for future use is the second one. Replace the 8U2 with a 16U2 at mega. The name "Uno" honors the impending release of Arduino 1.0 and means "one" in Italian.

Fig 1. ATmega328 Microcontroller

From now on, the Uno and version 1.0 of Arduino will serve as the reference versions. The most recent USB Arduino board in the lineup, the Uno serves as the platform's standard model when compared to earlier iterations. You have two options for powering the Arduino Uno: an external power supply or a USB connection. The power supply is chosen for you automatically.An AC-to-DC adapter (wall-wart) or a battery can supply external (non-USB) power. A 2.1mm center-positive connector must be inserted into the board's power jack in order to connect the adapter. It is possible to insert battery leads into the POWER connector's Gnd and Vin pin headers.The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

In this sensor we are using 2 Probes to be dipped into the Soil As per Moisture. We will get Analogue Output variations from 0.60volts - 12volts. Soil moisture sensors shown in figure 2 measure the water content in soil. A soil moisture probe is made up of multiple soil moisture sensors. One common type of soil moisture sensors in commercial use is a Frequency domain sensor such as a capacitance sensor. Another sensor, the neutron moisture gauge, utilizes the moderator properties of water for neutrons.

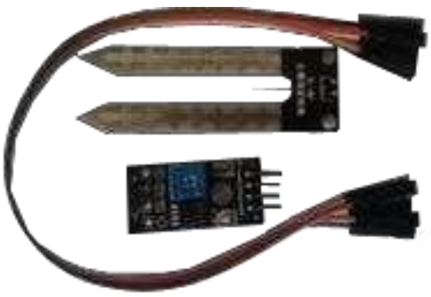

Fig 2. Soil Moisture Sensor SA SM01

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

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A humidity sensor (or hygrometer) figure 3 senses, measures, and reports both moisture and air temperature. The ratio of moisture in the air to the highest amount of moisture at a particular air temperature is called relative humidity. Relative humidity becomes an important factor when looking for comfort.

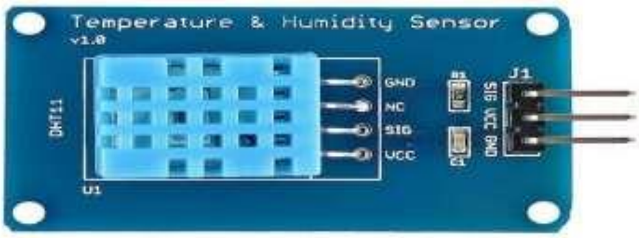

Fig 3. Humidity Sensor

Soil pH is one of the most important factors that can be overlooked in the garden. pH has impacts on the availability of nutrients and of the plants ability to take them up. If the pH of your garden soil is not in the optimal range for the plants, you are trying to grow you may end up having issues. Often plants grown in a soil that does not have the optimal pH don't produce or if they do their harvests are low while the plant may look stressed. On today's joint episode between the Testing Garden Assumptions and Urban Garden Series, I am going to look at soil pH, how to easily measure it and how you can adjust the pH over time if need be. pH is measured on a 14 -point scale with 0 being the most acidic 7 neutral and 14 the most basic shown in figure 4.

Fig 4 pH SensorWIFI

ESP8266 is Wi-Fi enabled system on chip (SoC) module developed by Espressif system. It is mostly used for the development of the Internet of Things (IoT) embedded applications. The ESP8266 is a low-cost Wi-Fi microchip shown in Figure 5.5 with full TCP/IP stack and microcontroller capability produced by Shanghai-based Chinese manufacturing company Espressif Systems.

The Arduino Uno offers multiple communication interfaces to interface with other microcontrollers, computers, or other Arduinos. Utilizing digital pins 0 (RX) and 1 (TX), the ATmega328 offers UART TTL (5V) serial connection capabilities. This serial communication is channeled over USB by an ATmega16U2 on the board, which shows up to computer programs as a virtual serial port. There is no need for an extra driver because the '16U2 firmware uses the normal USB COM drivers. On Windows, though, a.inf file is necessary.A serial monitor included into the Arduino software enables basic text data to be transferred to and from the Arduino board. When data is exchanged using the USB-to-serial chip and a USB connection to the computer, the board's RX and TX LEDs will light up (but not when utilizing pins 0 and 1 for serial transmission).

A Software Serial library can be used to enable serial communication via any of the Uno's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. See the documentation for further details. An I2C bus usage utility called Wire library is included with the Arduino program. For SPI communication, use the SPI library. The Arduino Uno may be programmed using the Arduino software. The bootloader pre-burned into the Arduino Uno's ATmega328 allows you to upload new code to it without needing.

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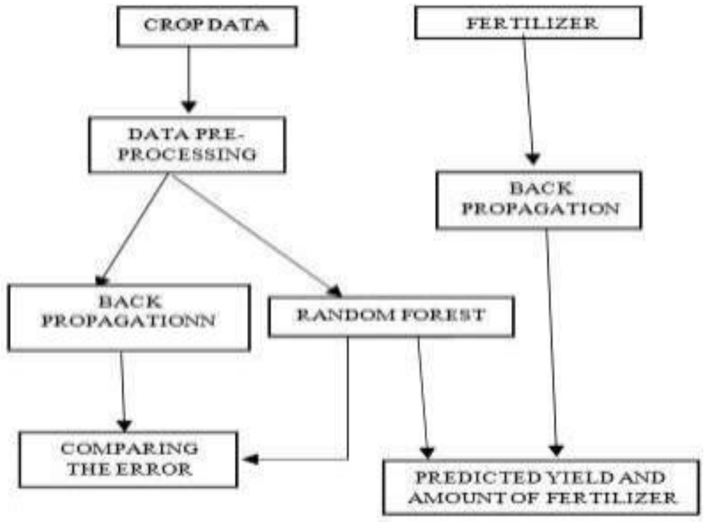

Fig 5. Methodology

The outcome of crop yield primarily depends on parameters such as variety of crop, seed type and environmental parameters such as sunlight (Temperature), soil (ph), water (ph), rainfall and humidity shown in Figure 5. By analysing the soil and atmosphere at region best crop in order to have more crop yield and the net crop yield can be predicted. This prediction will help the farmers. To choose appropriate crops for their farm according to the soil type, temperature, humidity, water level, spacing depth, soil pH, season, fertilizer, and months. India is a highly populated country and randomly change in the climatic conditions need to secure the world food resources. Farmers face serious problems in drought conditions. Type of soil plays a major role in the crop yield. Suggesting the use of fertilizers may help the farmers to make the best decision for their cropping situation. Based on soil type and soil PH we suggest what kind of fertilizer should be used for crop.

First Module: Dataset Training

Data patterns are recognized in this module, and correlations between various factors are calculated. The patterns in data and factors causing change can be studied using a variety of data visualization techniques. Crop, yield, and price predictions are made using algorithms such as Multiple Linear Regression and Random Forest. To determine the most suitable approach for prediction, we compare the accuracy of these algorithms using mean absolute percentage error shown in figure 6.

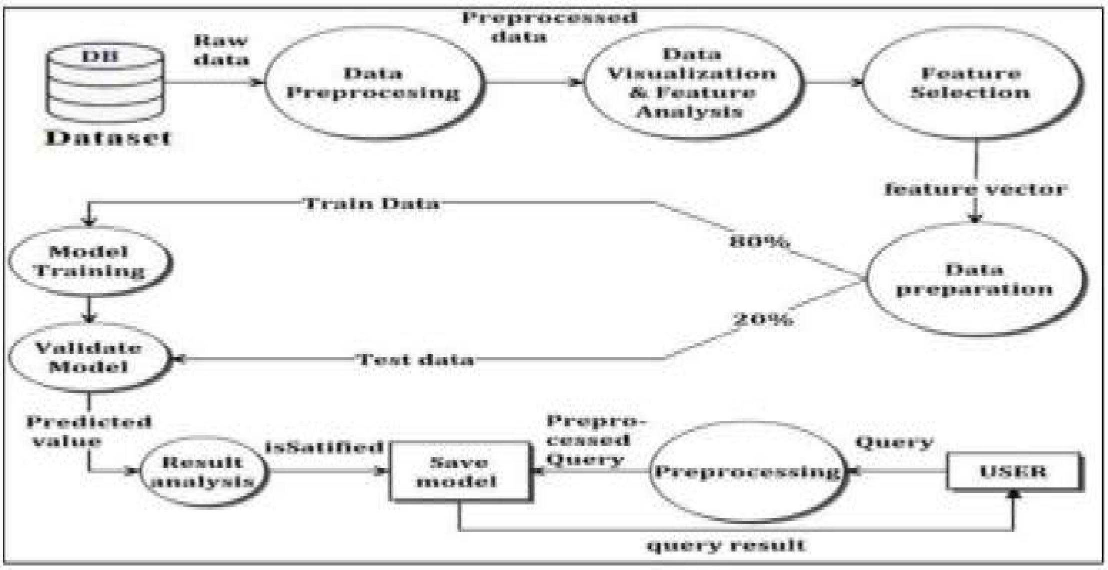

Fig 6. Dataset Training

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Second Module: Learning Algorithm Training

The second module uses prediction algorithms based on these algorithms. The model is trained for some data and tested for remaining data. After getting the user input these predictions algorithms give the correct output based on the previously available trained data and the range of the parameters provided shown in figure 7.

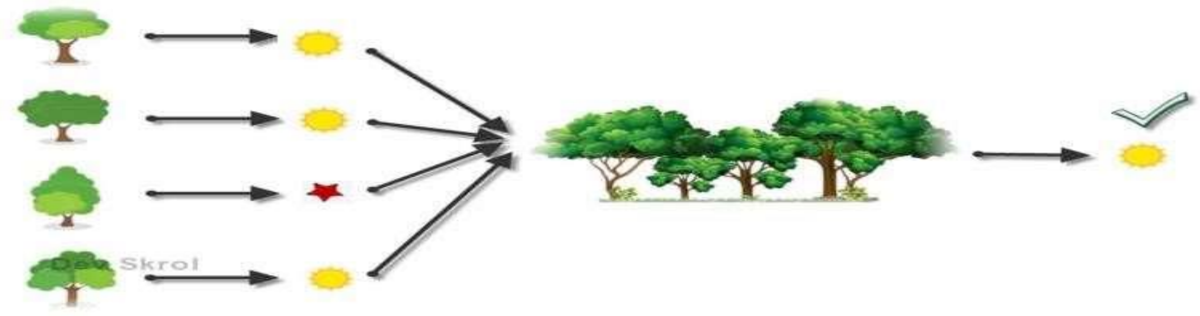

Fig 7. Learning Algorithm Training

Third Module: IoT Sensor

The Third module uses the measured data and uses functionalities to fetch the data from cloud platforms using IoT Sensors which can be directly used for input rather than the user's manual shown in figure 5.8.

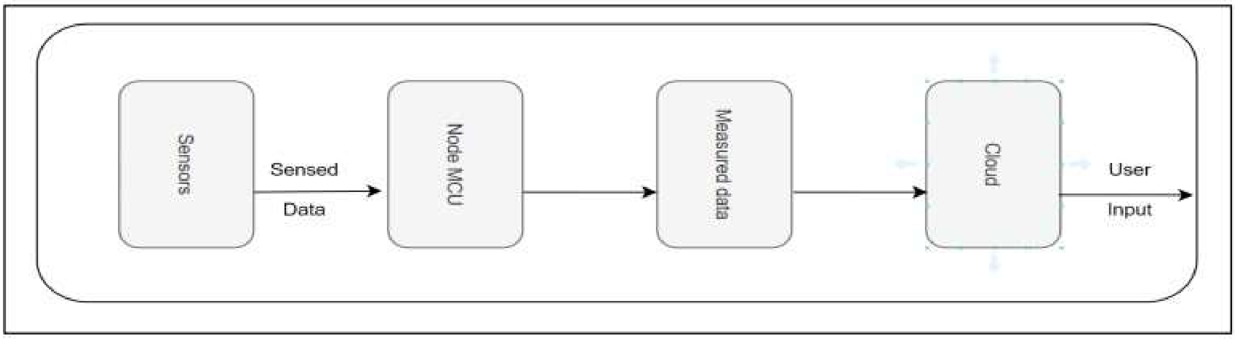

Fig 8. IoT Sensor

Fourth Module: User Access

Fourth module is the user access. This module provides an interface between the users and application. There are different parameters for different prediction objectives. Users can give input parameters. It also provides an estimate of the price of the crop produced based on the types of crops to be grown, the estimated yield of a particular crop, and the estimated yield of certain crops shown in figure 5.9.

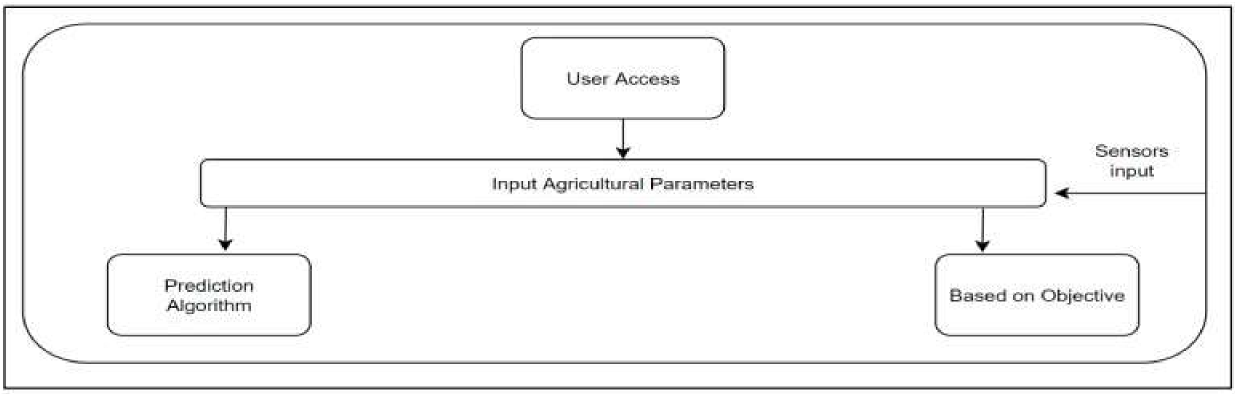

Fig 9. User Access

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Fifth Module: Final Prediction

Fifth module is the final part of the application in which after training and testing the data and taking user input suggestion results are provided to the users based on the comparison of parameters entered. Separate results are provided for the different objectives of the project and suggestion are provided and can furthermore developed by implementing the IOT Sensors in the user's access shown in figure 10.

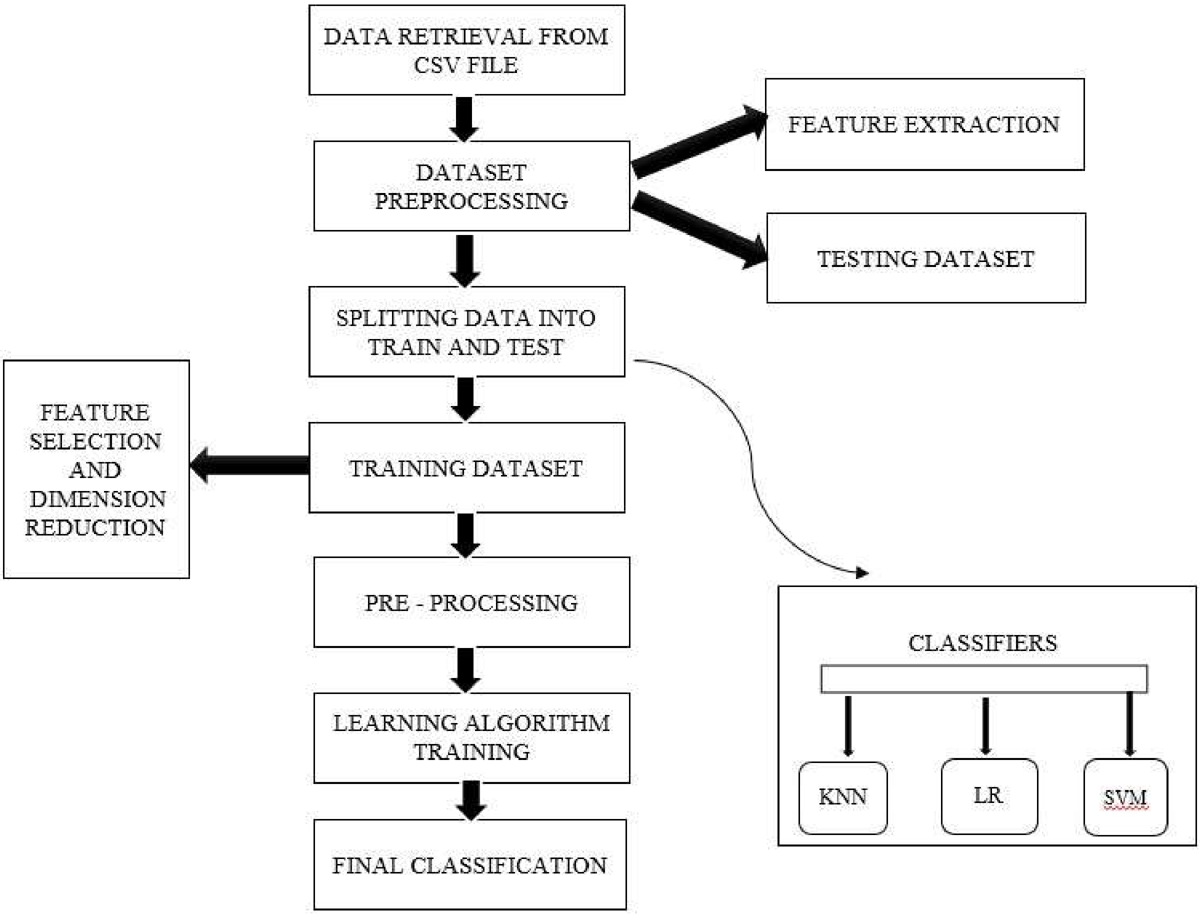

Fig 10. Final Prediction

IV. RESULT

The outlined project includes a thorough implementation strategy that combines software features that use Random Forest algorithms to predict crop yield with hardware components like the Arduino Uno microcontroller board, humidity sensor, pH sensor, soil moisture sensor SA SM01, and WiFi module ESP8266. Training of learning algorithms, user access, IoT sensor integration, data training, and final prediction modules are all part of the project methodology. This research uses machine learning algorithms and IoT sensor data to analyze soil and atmospheric conditions, among other things, in order to estimate crop output and suggest fertilizer use. The accuracy and dependability of the applied prediction models as well as the user-friendliness of the interface will ultimately decide the project's success, even though it offers a structured framework for agricultural management.

V. CONCLUSION

Anticipated triumphantly are crop output projections and the effective application of fertilizers. The algorithm and the very efficient harvest result are combined to create an effective algorithm. Our novel strategy for smart agriculture is presented in this study. Utilizing the Internet of Things and machine learning, two cutting-edge technologies. The accuracy of the outcome is improved by using both historical and real-time data. Furthermore, contrasting several machine learning techniques improves the system's accuracy.

The implementation of this method is expected to alleviate the challenges encountered by farmers and enhance both the volume and caliber of their output. Here, we can see that proposed system for Smart Management of Crop Cultivation using IoT and Machine Learning a smart system that can assist farmers in crop management by considering sensed parameters (temperature, humidity) and other parameters (soil type, rainfall) that predicts the most suitable crop to grow in that environment.

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