Smart Analysis And Prediction of Crops

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Abstract- *India being an agricultural country, its economy mainly depends on agriculture yield growth and allied agroindustry products. In India agriculture is largely influenced by rain water which is highly unpredictable. Agriculture growth depends on diverse soil parameters like nitrogen, phosphorous, potassium, crop rotation, soil moisture, surface temperature. It also depends on weather aspects which include temperature, rainfall etc. Agriculture is one of the major fields in our country and also plays a major role in our country's economy. India is the second –largest producer of agriculture crops and agriculture is one of the major and least paid occupation in India. Variability in seasonal climate conditions can have harmful effects, with incidents of drought reducing production. Developing better techniques to predict crop productivity in various climatic conditions can help farmer and other stakeholders in their decision making in terms of agronomy and crop choice.*

Keywords- NPK (Soil Parameters), soil moisture, surface temperature

I. INTRODUCTION

Agriculture is the most important sector of Indian Economy. 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.

Smart crop prediction is a technology-driven approach that utilizes advanced algorithms, data analysis techniques, and artificial intelligence to forecast crop yields, optimize agricultural practices, and enhance decision-making in the agricultural industry. By harnessing the power of machine learning and predictive analytics, smart crop prediction aims to improve productivity, reduce resource wastage, and mitigate risks associated with crop cultivation.
The traditional methods of crop prediction relied heavily on historical data, manual observations, and subjective judgment. However, with the advent of smart crop prediction, farmers and agricultural stakeholders can leverage real-time data from various sources such as satellite imagery, weather data, soil conditions, and crop health monitoring systems. These data sources provide a comprehensive understanding of the factors influencing crop growth and enable accurate predictions of yield, disease outbreaks, pest infestations, and other critical parameters.

Smart crop prediction algorithms analyze vast amounts of data to identify patterns, correlations, and trends. By considering multiple variables simultaneously, such as temperature, rainfall, humidity, soil composition, and crop genetics, these algorithms generate predictive models that can estimate crop yields and optimize cultivation strategies. Additionally, machine learning algorithms can adapt and improve over time as they learn from new data, enabling more accurate and precise predictions.

The benefits of smart crop prediction are manifold. Farmers can make informed decisions regarding seed selection, irrigation management, fertilization schedules, and pest control measures, leading to optimized resource utilization and increased profitability. By predicting potential crop failures or disease outbreaks in advance, farmers can take proactive measures to minimize losses and mitigate risks. Moreover, policymakers and agricultural organizations can utilize crop prediction data to develop effective strategies for food security, resource allocation, and sustainable agricultural practices.

However, it's important to note that smart crop prediction is not without its challenges. Accurate prediction requires reliable and up-to-date data, which may be limited in certain regions or for specific crops. Integration of different data sources and ensuring compatibility between various systems can also be complex. Additionally, the adoption of smart crop prediction technologies may require initial investments in infrastructure, data collection systems, and training programs for farmers and agricultural stakeholders.

Overall, smart crop prediction holds tremendous potential to revolutionize agriculture by enabling more efficient and sustainable farming practices. By harnessing the power of data and advanced analytics, it empowers farmers with valuable insights, optimizes crop management, and contributes to the global goal of achieving food security.

II. METHODOLOGY

- **CROP YEILD PREDICTION**

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. By analyzing the soil and atmosphere at particular 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.

- **FERTILIZER PREDICTION**

India is a highly populated country and randomly change in the climatic conditions need to secure the world food resources. Framers 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 particular crop.

- **RANDOM FOREST**

Random Forest algorithm is a supervised classification algorithm. We can see it from its name, which is to create a forest by some way and make it random. There is a direct relationship between the number of trees in the forest and the results it can get: the larger the number of trees, the more accurate the result. But one thing to note isthat creating the forest is not the same as constructing the decision with information gain or gain index approach.

SYSTEM ANALYSIS AND DESIGN

Analysis is the process of breaking a complex topic or substance into smaller parts to gain a better understanding of it. Analysts in the field of engineering look at requirements, structures, mechanisms, and systems dimensions. Analysis is an exploratory activity. The Analysis Phase is where the project lifecycle begins. The Analysis Phase is where you break down the deliverables in the high-level Project Charter into the more detailed business requirements. The Analysis Phase is also the part of the project where you identify the overall direction that the project will take through the creation of the project strategy documents.

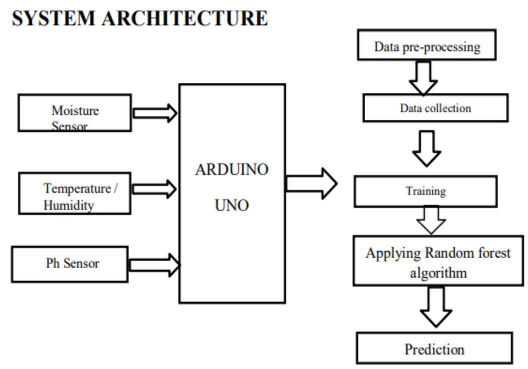

Figure 1: System Architecture

HIGH LEVEL DESIGN

In the high-level design, the proposed functional and non-functional requirements of the software are depicted. Overall solution to the architecture is developed which can handle those needs. This chapter involves the following consideration.

• Design consideration • Data flow diagram

DATA PRE-PROCESSING

Data pre-processing includes removing of the unwanted attributes from our datasets. Feature extraction is done in order to extract only the attributes that affect the price and yield of a crop like rainfall, temperature, location, area, production and yield.

Data preprocessing plays a crucial role in smart crop prediction systems as it involves transforming and preparing the raw data collected from various sources for analysis and modeling. Here are some key steps involved in data preprocessing for smart crop prediction.

Data Collection: The first step is to collect relevant data from different sources such as NPK and pH sensors, weather stations, satellite imagery, historical crop data, and farmer inputs. This data could include information on soil nutrient levels, pH values, weather conditions, crop types, planting dates, and yield records.

Data Cleaning: Raw data often contains missing values, outliers, noise, or inconsistencies. Data cleaning involves handling missing data by either removing incomplete records or imputing missing values using appropriate techniques.

Outliers and noisy data points may be identified and treated accordingly, ensuring data quality.

Data Integration: Data from multiple sources need to be integrated into a unified format. This involves aligning timestamps, handling different data resolutions, and merging relevant data based on common identifiers such as location or crop type.

Feature Selection: Not all collected features may be relevant or contribute significantly to crop prediction. Feature selection techniques help identify the most important features that have the most impact on the target variable (crop yield prediction). This reduces dimensionality and computational complexity.
Feature Scaling: Different features may have varying scales and units. Scaling techniques such as normalization or standardization are applied to bring all features to a common scale. This ensures that no single feature dominates the prediction process due to its larger magnitude.

Feature Engineering: Additional meaningful features can be derived from the existing data. For example, based on historical weather data, features such as average temperature, rainfall patterns, or growing degree days can be calculated, which may provide valuable insights for crop prediction.

Data Split: The preprocessed data is typically divided into training, validation, and testing sets. The training set is used to build the prediction models, the validation set helps fine-tune model parameters, and the testing set evaluates the final model's performance.

Data Normalization: In some cases, it may be necessary to normalize the target variable (crop yield) to a specific range or apply a logarithmic transformation to handle skewed distributions. This ensures that the data satisfies certain assumptions and improves model performance.

Data Balancing: If there is a significant class imbalance in the target variable (e.g., high yield vs. low yield), techniques like oversampling or undersampling can be applied to balance the data and prevent bias towards the majority class.

Data Encoding: Categorical variables (such as crop types) are encoded into numerical representations using techniques like one-hot encoding or label encoding to make them compatible with machine learning algorithms.

By performing these data preprocessing steps, the collected data is transformed into a clean, consistent, and well-structured format, ready for analysis and model training in smart crop prediction systems. Effective data preprocessing enhances the accuracy and reliability of the prediction models, ultimately helping farmers make informed decisions about crop management, resource allocation, and yield optimization.

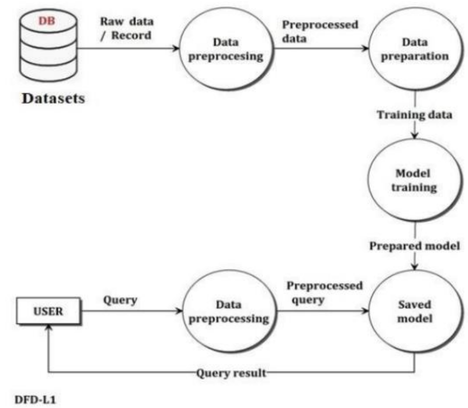

Figure 2: Data Pre-Processing

ANALYSIS AND PREDICTION

In this module, patterns in data is recognized, percentage correlation between various factors affecting crop yield and price are determined. Various data visualization techniques are used to study the patterns in data and factors causing change. Algorithms like Multiple Linear Regression and Random Forest are used to predict crop yield and price. The accuracy of these algorithms are compared using mean absolute percentage error thus helping us determine the most suitable approach for prediction.

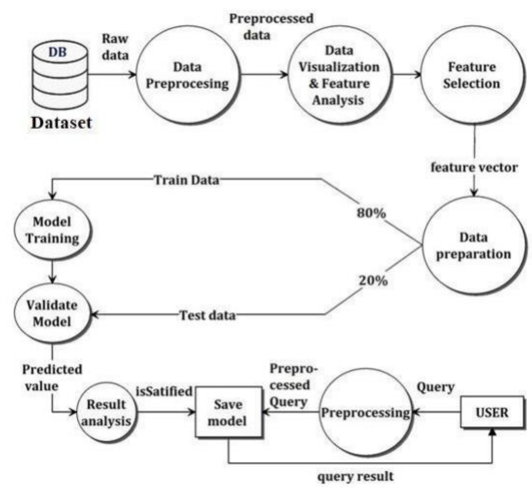

Figure 3: Data Model

LOW LEVEL DESIGN

During the detailed phase, the view of the application developed during the high-level design is broken down into modules and programs.

USE CASE DIAGRAM

A use case diagram at its simplest is a representation of a user's interaction with the system that shows the relationship between the user and the different use cases in which the user is involved. A use case diagram can identify the different types of users of a system and the different use cases and will often be accompanied by other types of diagrams as well. While a use case itself might drill into a lot of detail about every possibility, a use case diagram can help provide a higher-level view of the system. It has been said before that "Use case diagrams are the blueprints for your system". They provide the simplified and graphical representation of what the system must do.

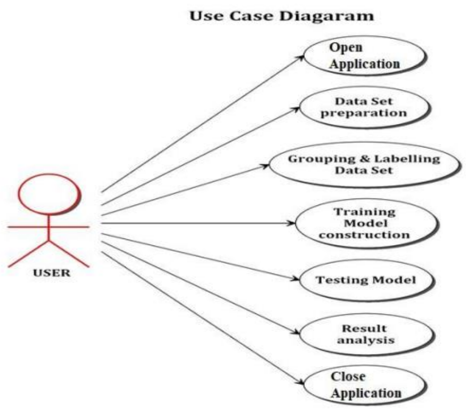

Figure 4: User Case Diagram

III. IMPLEMENTATION

A. HardwareImplementation

Implementation is the carrying out, execution or practice of a plan, a method, or any design, idea, model, specification, standard or policy for doing something. As such, implementation is the action that must follow any preliminary thinking in the order for something to actually happen. Implementations allow the users to take over its operation for use and evaluation. It involves training the users to handles the system and plan for a smooth conversion. Implementation is a process of ensuring that the information system is

- Constructing a new system from scratch.
- Constructing a new system from the existing system.

1. Arduino

The Arduino Uno, a popular microcontroller board, can be utilized in crop prediction systems to collect data, monitor environmental conditions, and assist in decision-making processes. Here's how the Arduino Uno can be applied in crop prediction:

- Sensor Integration: The Arduino Uno can interface with various sensors to measure environmental parameters critical for crop prediction. For example, temperature and humidity sensors can monitor the ambient conditions, soil moisture sensors can measure the water content in the soil, and light sensors can determine the amount of sunlight received by the crops. These sensors can be connected to the Arduino Uno's digital or analog input pins to collect real-time data.
- Data Acquisition and Processing: The Arduino Uno can gather sensor data and process it using its built-in computational capabilities. It can execute algorithms and calculations to analyze the collected data and extract meaningful information. For instance, it can calculate temperature differentials, determine moisture levels, or generate statistical averages based on the sensor inputs.
- Connectivity: The Arduino Uno can be equipped with wireless communication modules such as Wi-Fi or GSM modules. This connectivity enables the device to transmit data to a central server, cloud platform, or other connected devices for further analysis. By sending the collected sensor data to a remote location, it becomes possible to integrate it with other data sources and employ advanced machine learning algorithms for crop prediction.
- Decision Support System: The Arduino Uno can serve as a decision support system by providing real-time information to farmers or agricultural stakeholders. Based on the analyzed data, the Arduino Uno can trigger alerts or notifications when specific conditions are met, such as low moisture levels, high temperatures, or disease outbreaks. This information can help farmers take timely actions to optimize irrigation, apply fertilizers, implement pest control measures, or adjust crop management strategies.
- Automation and Control: The Arduino Uno can also control actuators or devices that influence crop growth conditions. For instance, it can control irrigation systems, adjust greenhouse ventilation, or activate shading mechanisms based on the sensor readings. By automating these processes, farmers can maintain optimal environmental conditions for crop growth and reduce manual intervention.
- Data Logging and Visualization: The Arduino Uno can log sensor data over time, storing it in memory or external storage devices such as SD cards. This data can be later retrieved for analysis, visualization, and pattern recognition. Graphical interfaces or displays can be connected to the Arduino Uno to present the data in a

user-friendly manner, allowing farmers to monitor the crop conditions conveniently.

It's important to note that while the Arduino Uno can serve as a valuable component in a crop prediction system, it is typically part of a larger architecture that involves data analysis platforms, machine learning algorithms, and cloud-based services. The Arduino Uno's role lies in data collection, local processing, and control, while more complex analysis and prediction tasks are often performed on more powerful computing platforms.

- **ATmega328 Microcontroller**

The ATmega328 microcontroller, which is commonly used on Arduino Uno boards, can also be utilized in crop prediction systems to collect data, monitor environmental conditions, and aid in decision-making processes. Here's how the ATmega328 microcontroller can be applied in a crop prediction system:

Sensor Integration: The ATmega328 microcontroller can interface with various sensors, such as temperature, humidity, soil moisture, light, and atmospheric sensors. These sensors provide crucial data points for crop prediction. By connecting these sensors to the appropriate digital or analog pins of the ATmega328 microcontroller, it can collect real-time environmental data.

Data Acquisition and Processing: The ATmega328 microcontroller can collect and process sensor data using its onboard computational capabilities. It can execute algorithms and calculations to analyze the collected data and extract meaningful information. This can include calculating averages, identifying patterns, or performing simple statistical analysis based on the sensor inputs.

Connectivity: The ATmega328 microcontroller can be integrated with wireless communication modules like Wi-Fi or GSM modules. This enables the device to transmit data to a central server, cloud platform, or other connected devices. By sending the collected sensor data to a remote location, it becomes possible to integrate it with other data sources and utilize advanced machine learning algorithms for crop prediction.

Decision Support System: The ATmega328 microcontroller can act as a decision support system by providing real-time information to farmers or agricultural stakeholders. Based on the analyzed data, the microcontroller can trigger alerts or notifications when specific conditions are met, such as low moisture levels, high temperatures, or disease outbreaks. These notifications can help farmers take timely actions to optimize irrigation, apply fertilizers, implement pest control measures, or adjust crop management strategies.

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While the ATmega328 microcontroller provides essential functionalities for data collection and local processing, it's important to note that more complex analysis and prediction tasks are typically performed on more powerful computing platforms. The microcontroller is part of a larger system that may include additional components, software, and cloud-based services to fully implement a comprehensive crop prediction system.

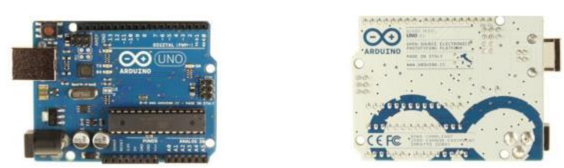


Figure 5: ATmega328 Microcontroller

2. Moisture Sensor SA SM01

The Moisture Sensor SA SM01 is a specific type of soil moisture sensor that can be integrated into a crop prediction system to monitor soil moisture levels, which is a critical parameter for crop growth and yield estimation. Here's how the Moisture Sensor SA SM01 can be used in a crop prediction system:

Sensor Installation: The Moisture Sensor SA SM01 is typically installed in the soil at a suitable depth, considering the crop's root zone. Multiple sensors can be distributed across the field to capture variations in soil moisture content. The sensor is connected to the crop prediction system, which can include a microcontroller like Arduino Uno or ATmega328.

Data Collection: The Moisture Sensor SA SM01 continuously measures the moisture content in the soil at its location. It provides analog or digital output signals that represent the soil moisture levels. The connected microcontroller reads these signals and collects the data from the sensor.

Data Processing: The microcontroller, such as Arduino Uno or ATmega328, processes the data collected from the Moisture Sensor SA SM01. It can convert analog signals to digital values, perform calibration, and apply algorithms to normalize the readings or remove noise. The processed data is then ready for further analysis.

Integration with Crop Prediction System: The soil moisture data from the Moisture Sensor SA SM01 is integrated into the crop prediction system. This system can involve other sensors, such as temperature, humidity, and light sensors, to collect comprehensive environmental data. The crop prediction system may also incorporate machine learning algorithms or mathematical models for yield estimation or disease prediction.

Decision-Making and Irrigation Management: The soil moisture data collected by the Moisture Sensor SA SM01 is crucial for irrigation management. By monitoring soil moisture levels, the crop prediction system can determine when and how much water should be applied to the crops. This information helps optimize irrigation scheduling, prevent over- or under-watering, and ensure that the crops receive the appropriate amount of water for optimal growth.

Yield Estimation and Crop Management: Soil moisture data from the Moisture Sensor SA SM01, combined with other environmental data and predictive models, can contribute to yield estimation and crop management decisions. The crop prediction system can analyze the soil moisture trends, correlate them with crop growth stages, and predict potential yield outcomes. This information assists farmers in making informed decisions about fertilization, disease management, and harvest planning.

By integrating the Moisture Sensor SA SM01 into a crop prediction system, farmers and agricultural stakeholders can obtain real-time information about soil moisture conditions. This data enables them to optimize irrigation practices, enhance crop management strategies, and make more accurate predictions regarding crop yields and overall agricultural productivity.

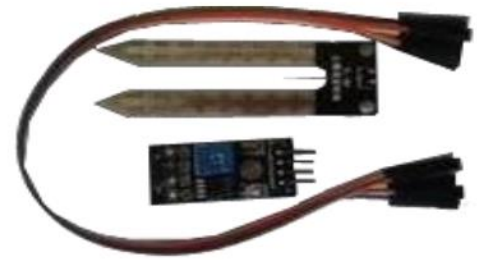


Figure 6: Moisture Sensor SA SM01

3. Humidity sensor

A humidity sensor (or hygrometer) 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.

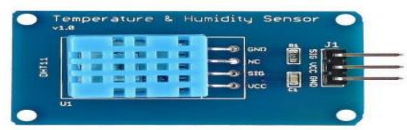


Figure 7: Humidity Sensor

4. PH / NPK Sensor:

NPK and pH sensors play crucial roles in crop prediction systems by providing valuable information about soil fertility and conditions.

NPK Sensors:

NPK refers to the three essential nutrients required by plants: nitrogen (N), phosphorus (P), and potassium (K). NPK sensors are used to measure the levels of these nutrients in the soil, which helps in determining the overall fertility and health of the soil. Here's how they contribute to crop prediction systems:

a. Nutrient Monitoring: NPK sensors measure the concentration of nitrogen, phosphorus, and potassium in the soil, allowing farmers to monitor nutrient availability. This data helps optimize fertilization practices, ensuring that crops receive adequate nutrients for healthy growth.

b. Yield Prediction: By analyzing the NPK levels throughout the growing season, crop prediction systems can estimate potential crop yields. This information assists farmers in making informed decisions regarding crop management, harvest planning, and resource allocation.

c. Nutrient Management: NPK sensors enable farmers to precisely apply fertilizers based on the specific nutrient needs of their crops. This promotes efficient nutrient management, reduces fertilizer waste, and minimizes environmental impact.

pH Sensors:

pH sensors measure the acidity or alkalinity of the soil, indicated by the soil's pH level. The pH of the soil significantly affects nutrient availability to plants. pH sensors are essential in crop prediction systems for the following reasons:

a. Soil Acidity/Alkalinity Assessment: pH sensors provide real-time measurements of soil pH, helping farmers assess whether the soil is acidic, alkaline, or neutral. Different crops have varying pH requirements, and knowing the soil pH aids in selecting suitable crops and determining the need for pH adjustment.

b. Nutrient Availability: Soil pH directly affects nutrient availability to plants. Some nutrients become more or less accessible to plants based on the pH level. pH sensors assist in identifying nutrient deficiencies or excesses, enabling farmers to adjust soil conditions for optimal nutrient uptake.

c. Crop Suitability: Certain crops thrive within specific pH ranges. pH sensors help determine if the soil pH aligns with the crop's requirements, aiding in crop selection and predicting potential yields accurately.

Integrating NPK and pH sensor data into crop prediction systems allows farmers to make data-driven decisions, optimize resource management, enhance crop yields, and minimize environmental impact by applying precise and targeted farming practices.

Figure 8: NPK/Ph Sensor

B. Software Implementation

The Arduino Uno is a popular microcontroller board widely used in electronic projects and prototyping. It is based on the Atmel ATmega328P microcontroller and offers a range of features that make it suitable for beginners and experienced users alike. Here are some key aspects of the Arduino Uno:

- Microcontroller: The Arduino Uno is built around the ATmega328P microcontroller, which runs at 16 MHz and has 32KB of flash memory for storing code, 2KB of SRAM, and 1KB of EEPROM. It also includes various built-in peripherals like digital I/O pins, analog inputs, timers, UART, SPI, and I2C interfaces.
- I/OPins: The Arduino Uno has a total of 14 digital input/output pins, among which 6 can be used as PWM (Pulse Width Modulation) outputs. These pins allow you to interface with various electronic components such as sensors, displays, motors, and more. Additionally, there are 6 analog input pins for reading analog signals.
- Programming: Arduino Uno can be programmed using the Arduino programming language, which is based on Wiring, a simplified variant of C++. The Arduino development environment provides a user-friendly interface for writing, compiling, and uploading code to the board. It also offers a vast library of pre-written functions that simplify complex tasks.
- Power Supply: The Arduino Uno can be powered via a USB connection or an external power source. It has a built-in voltage regulator that allows it to be powered with a DC voltage between 7V and 20V. Additionally, the board provides 3.3V and 5V output pins for powering external components.

- Shields: Arduino Uno is compatible with a wide range of add-on boards called "shields." Shields offer additional functionality like Ethernet connectivity, wireless communication (Wi-Fi, Bluetooth), motor control, display interfaces, and more. They can be easily plugged into the Arduino Uno, extending its capabilities.
- Community and Documentation: Arduino has a large and active community of users and developers. This community provides extensive documentation, tutorials, sample projects, and forums where users can seek help and share their knowledge and experiences.

It communicates using the original STK500 protocol (reference, C header files).

Figure 9: Arduino Uno

C. Performance Analysis

Analysis is the process of breaking a complex topic or substance into smaller parts to gain a better understanding of it. Analysts in the field of engineering look at requirements, structures, mechanisms, and systems dimensions. Analysis is an exploratory activity. The Analysis Phase is where the project lifecycle begins. The Analysis Phase is where you break down the deliverables in the high-level Project Charter into the more detailed business requirements. The Analysis Phase is also the part of the project where you identify the overall direction that the project will take through the creation of the project strategy documents. Gathering requirements is the main attraction of the Analysis Phase. The process of gathering requirements is usually more than simply asking the users what they need and writing their answers down.Depending on the complexity of the application, the process for gathering requirements has a clearly defined process of its own. This process consists of a group of repeatable processes that utilize certain techniques to capture, document, communicate, and manage requirements.

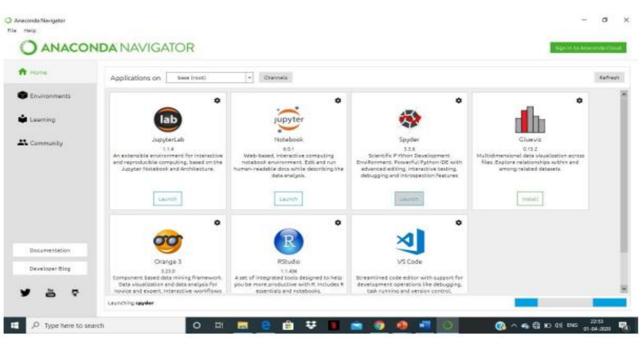
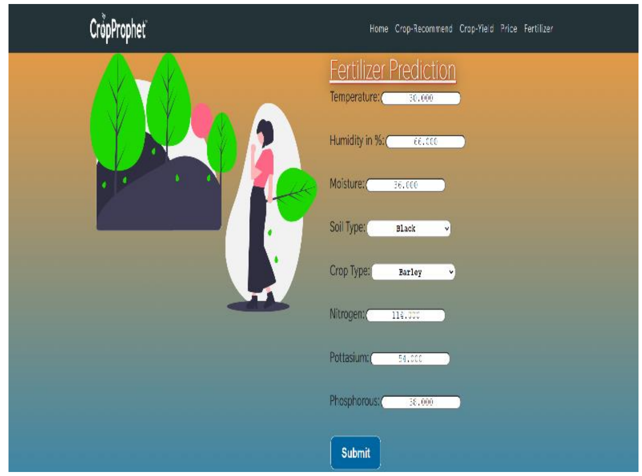


Figure 10: Anaconda Nagivator

IV. RESULTS

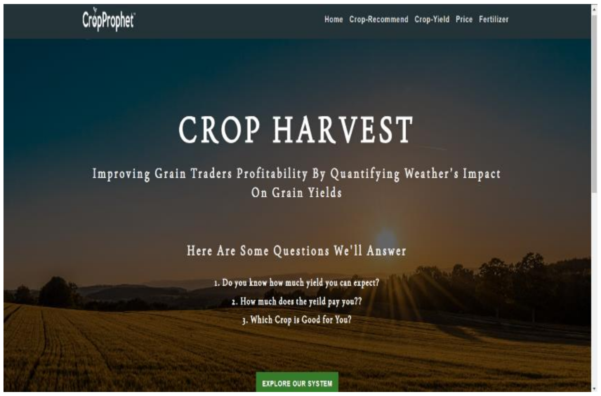
MODULE-1: FERTILIZER PREDICTION



MODULE-2: CROP PRICE

MODULE-3 CROP RECOMMEND

MODULE-4: HOME PAGE:



MODULE-5:CROP YIELD

V. CONCLUSION

Agriculture is the backbone of counties like India. However, the usage of technology towards agriculture is to be given paramount importance towards preclusion agriculture. This paper proposes a system which will help farmers to have an idea of yield estimates based on weather parameters and area under cultivation Using this farmer can make decisions on whether to grow that particular crop or go for alternate crop in case yield predictions are unfavorable. This research work can be enhancing to the next level. We can build a recommender system of agriculture production and distribution for farmer. By which farmers can make decision in which season which crop should grow so that they can get more use and benefit accordingly. This system is work for structured dataset. In future we can implement data independent system also. It means format of data whatever, our system should work with same efficiency. In future developing the web application based on this ideology and make the user use this easily and help the user to understand the yield of the crop, he is going to crop in that season.

In conclusion, a smart crop prediction system integrated with NPK and pH sensors offers significant benefits for farmers and agricultural practices. By incorporating these sensors into the system, farmers can effectively monitor soil fertility, optimize nutrient management, and make data-driven decisions to enhance crop yields. Here are the key takeaways:

- Soil Fertility Monitoring: NPK sensors provide real-time measurements of nitrogen, phosphorus, and potassium levels in the soil, allowing farmers to monitor soil fertility. This information helps in identifying nutrient deficiencies or excesses and enables precise fertilization practices.
- Yield Prediction: Continuous monitoring of NPK levels throughout the growing season provides valuable data for crop prediction. By analyzing the nutrient data and other environmental factors, the system can estimate potential crop yields, assisting farmers in planning harvests and optimizing resource allocation.
- Nutrient Management: NPK sensors enable farmers to apply fertilizers precisely based on crop nutrient requirements. This promotes efficient nutrient management, reduces fertilizer waste, and minimizes environmental impact, leading to sustainable farming practices.
- pH Assessment: pH sensors play a crucial role in determining soil acidity or alkalinity. They provide insights into nutrient availability and help farmers select appropriate crops and adjust soil conditions accordingly. pH sensors also aid in predicting crop suitability and optimizing yield potential.

Integrating NPK and pH sensors into a smart crop prediction system empowers farmers with real-time data, enhances decision-making, and promotes efficient resource utilization. By leveraging this technology, farmers can optimize crop yields, improve sustainability, and make informed choices to achieve higher productivity in their agricultural practices.

VI. ACKNOWLEDGEMENT

We would like to express our special thanks of gratitude to our professors Dr. Vidyarani H J ofDr. Ambedkar Institute of Technology, Bengaluru who supported and helped us doing the research on this paper. And also, we would thank Department of Information Science and Engineering of Dr. Ambedkar Institute of Technology which gave us this opportunity to do this project “SMART ANALYSIS AND PREDICTION OF CROPS”, which helped us to learn new things and new technologies in this field.

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