**SOIL NUTRITION MANAGEMENT USING IoT and MACHINE LEARNING: AGRI-TECH**

**BACHELOR OF TECHNOLOGY**

CSE

SUBMITTED BY

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**INTRODUCTION –**

Agriculture is the foundation of many economies around the world, and it is critical to feeding the world's growing population. Furthermore, rising food demand necessitates farmers to develop new methods of increasing output and efficiency. As a result, agricultural technology, also known as Agri-Tech, has become the solution for farmers to overcome various operational challenges.

Agri-Tech is the application of technology and technological innovation to improve the efficiency and output of agricultural processes. It is applying technology to improve all aspects of farming and growing. As a result, everything you need to know about agricultural technology(Agri-Tech) becomes an important field of inquiry for most farmers.

Agri-Tech assists farmers in overcoming operational challenges such as financing, supplies, and crop productivity. With the help of Agri-Tech, farmers can increase overall production, reduce their impact on natural ecosystems, and ensure safer growing conditions. They can also make safer foods available to consumers on the market. Furthermore, Agri-Tech provides farmers with improved worker facilities, increased efficiencies, and lower prices. For example, the use of artificial intelligence for climate and weather prediction and biotechnology for developing resilient crops result from Agri-Tech. Similarly, agriculture sensors are some key technologies that play a vital role in farmers' lives.

Agri-Tech plays a crucial role in the agriculture industry by helping farmers overcome various challenges they face in their day-to-day operations. Applying technology and technical innovations in agriculture have significantly increased efficiency and output. Agri-Tech helps farmers in various aspects of their farming operations. From increasing crop production to reducing water, fertilizer, and pesticides to improving working conditions for farm workers. In essence, Agri-Tech plays a vital role in making the agriculture industry more efficient and sustainable.

Agricultural **development** practices over a while have been perceived to exploit natural resources faster than they could be renewed. Exponential growth in the human population has resulted in demand for food and shelter, which the “natural” carrying capacity of the land is under pressure to provide.

Natural imbalance is visible in pollution, soil degradation, wildlife population decline, and human-created alterations of flora and fauna. It is reasonable to assume that human population growth will continue and place greater demands on the Agri-ecosystem. Thus, technology has and will continue to play a major role in **agriculture and sustainable development** going forward.

Technology has a major role in farming and agriculture practices; and with the advent of digital technology, the scope has widened. Innovation in agriculture is leading an evolution in agricultural practices, thereby reducing losses and increasing efficiency. This is positively impacting farmers. The use of digital and analytic tools is driving continuous improvement in agriculture and the trend is here to stay, resulting in improving crop yields and helping to increase the income of the farming community.

**RATIONALE –**

One of the biggest threats to our future food security is land degradation and its associated loss in soil productivity. Life beneath the soil is the basis of life above the soil. But around the world, life in the soil is dying. Nearly 27,000 species go extinct every year due to soil degradation. 3,00,000 farmers commit suicide every year due to crop failure. We lose 12 million hectares of topsoil across the world owing to sustainable agriculture practices. A full 90 percent of the Earth's precious topsoil is likely to be at risk by 2050, according to the UN Food and Agriculture Organisation, FAO. In a bid to protect soil globally and help farmers, the FAO warned that the equivalent of one soccer pitch of earth erodes, every five seconds.

We are committed to do sustainable production while optimizing yield and preventing the

risk of crop loss. The main problem faced by farmers in doing organic farming is the

shortage of nutrient content in the soil, which results in lesser yield or crop failure. Changing

from chemical to organic farming requires 2-3 years of time for the soil to adapt and the

problem is the farmers in India are majorly small-scale farmers who do not have the money

to bear 2 to 3 years of crop loss.

**OBJECTIVES –**

Our Agri-Tech-based project aims to enhance crop yield by implementing electrochemical sensors while promoting the adoption of organic farming practices. By leveraging advanced sensing technologies, we aim to monitor and optimize crucial environmental parameters such as soil moisture, pH levels, nutrient composition, and temperature, among others, to create optimal growing conditions for crops. This approach seeks to maximize agricultural productivity while minimizing resource wastage and environmental impact.

Additionally, our project aligns with the United Nations Sustainable Development Goals (SDGs) by contributing to several key targets. Specifically, we aim to address SDG 2 (Zero Hunger) by increasing crop yield and ensuring food security, SDG 12 (Responsible Consumption and Production) by promoting sustainable agricultural practices, and SDG 13 (Climate Action) by minimizing the environmental footprint of conventional farming methods. By integrating technology, sustainability, and organic farming principles, our project strives to pave the way for a more efficient and eco-friendly agricultural sector.

Overall, our project seeks to harness the potential of Agri-Tech innovations, specifically electrochemical sensors, to optimize crop yield, foster organic farming practices, and contribute to the achievement of various Sustainable Development Goals.

**LITERATURE REVIEW –**

Table-1 : Literature Review

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sr. no. | Journals | Year | Writers | Findings |
| 1 | Digitalization in the agri-food industry: the relationship between technology and sustainable development | 2020 | 1. Maria Carmela Annosi  2. Federica Brunetta  3. Francesca Capo  4. Laurens Heideveld | To understand the diversity of challenges emerging in the agri-food industry from the usage of new technologies and challenges. |
| 2 | Role of IoT Technology in Agriculture: A Systematic Literature Review | 2020 | 1. Muhammad Shoaib Farooq  2. Shamyla Riaz  3. Adnan Abid  4. Tariq Umer  5. Yousaf Bin Zikria | 1. Air Monitoring  2. Soil Monitoring  3. Environmental Condition Monitoring  4. Crop and Plant Growth Monitoring  5. Humidity Monitoring |
| 3 | The Digitalization of Agriculture and Rural Areas: Towards a Taxonomy of the Impacts | 2021 | 1. Silvia Rolandi  2. Gianluca Brunori  3. Manlio Bacco  4. Ivnao Scottica | Thanks to digital technologies, it will be increasingly possible to determine with extreme precision which crops to grow according to market trends and when to intervene with agricultural work. |
| 4 | Using machine learning-based seed harvest moisture predictions to improve a computer-assisted agricultural farm operation | 2019 | 1. Xiao Yang  2. Yao Xie  3. Allan Trapp  4. Matthew Sorge  5. Bruce J. Schnicker | Machine  Learning can help farmers identify optimal planting and irrigation schedules, as well as predict ideal conditions for crop growth.  ML is used in earlywarning systems that alert farmers about potential outbreak. |

**FEASIBILITY STUDY -**

1. **Feasibility :**

The feasibility of developing a Machine Learning model for crop safety is supported by several factors. Firstly, the availability of historical and real-time data, including environmental conditions, crop health indicators, pest and disease occurrences, and farming practices, provides a robust foundation for training and validating predictive models. Advances in sensor technology and remote sensing further enhance data collection capabilities. Secondly, the increasing accessibility of computational resources and cloud-based platforms enables the implementation of complex Machine Learning algorithms. Thirdly, collaborations between agricultural experts, data scientists, and technology developers can bring together the necessary domain knowledge and technical expertise to create and refine the models. Lastly, the successful integration of Machine Learning into various sectors, including agriculture, demonstrates the potential for its application in enhancing crop safety.

1. **Need :**

The need for a Machine Learning-based approach to crop safety arises from the escalating challenges faced by modern agriculture. As climate change introduces unprecedented variability in weather patterns and intensifies the prevalence of pests and diseases, traditional approaches to crop management prove insufficient. The need to optimize resource utilization, reduce environmental impacts, and secure crop yields is paramount. A predictive model that can identify stressors in advance and provide customized recommendations aligns with the demand for proactive and data-driven solutions in agriculture. Additionally, the projected global population growth underscores the urgency of improving crop safety to ensure a stable and secure food supply.

1. **Significance :**

One of the biggest threats to our future food security is land degradation and its associated loss in soil productivity. Life beneath the soil is the basis of life above the soil. But around the world, life in the soil is dying. Nearly 27,000 species go extinct every year due to soil degradation. 3,00,000 farmers commit suicide every year due to crop failure. We lose 12 million hectares of topsoil across the world owing to sustainable agriculture practices. A full 90 percent of the Earth's precious topsoil is likely to be at risk by 2050, according to the UN Food and Agriculture Organisation, FAO. In a bid to protect soil globally and help farmers, the FAO warned that the equivalent of one soccer pitch of earth erodes, every five seconds.

**METHODOLOGY –**

1. **IoT Sensor Deployment:**

* Identify target agricultural fields for implementing the IoT sensor network.
* Select and install a variety of sensors to capture relevant soil data. These sensors may include soil moisture sensors, temperature sensors, pH sensors, and nutrient level sensors.
* Set up a wireless communication infrastructure to transmit data from the sensors to a central data repository.

1. **Data Collection and Storage:**

* Continuously collect data from the deployed IoT sensors. This data should include real-time measurements of soil moisture, temperature, pH levels, and nutrient content.
* Store the collected data securely in a centralized database. Implement data cleaning and pre-processing techniques to ensure data quality.

1. **Machine Learning Model Development:**

* Pre-process the data to handle missing values, outliers, and noise.
* Split the data into training, validation, and testing sets.
* Develop machine learning models, such as regression or classification models, to predict soil nutrition requirements.
* Experiment with different algorithms and hyperparameters to optimize model performance.
* Train and validate the models using historical data, and fine-tune them as needed.

1. **User Interface Development:**

* Create a user-friendly interface that allows farmers to access soil health information and recommendations.
* Design the interface to display real-time data from the IoT sensors, as well as predictions generated by the machine learning models.
* Ensure the interface is accessible through web or mobile platforms for ease of use in the field.

1. **Field Testing and Validation:**

* Collaborate with local farmers to conduct field tests in the selected agricultural fields.
* Implement the IoT sensor network and integrate it with the machine learning model and user interface.
* Monitor the system's performance in real-world agricultural conditions.
* Collect feedback from farmers regarding the usability and effectiveness of the system.

**FACILITIES REQUIRED FOR PROPOSED WORK –**

**Software Requirements:**

1. **IoT Development Tools:**

IoT development platforms like Arduino IDE or Raspberry Pi software for programming and managing IoT sensors.

1. **Machine Learning and Data Analysis Tools:**

Python programming language for machine learning model development.

Machine learning libraries like TensorFlow, scikit-learn, or PyTorch for building and training predictive models.

Data analysis and visualization tools like pandas, Matplotlib, and Jupyter Notebook for data exploration and model evaluation.

1. **Database Management:**

A relational or NoSQL database system to store and manage collected sensor data. Options include MySQL, PostgreSQL, MongoDB, or Firebase.

1. **Web and Mobile Development Tools:**

We are working on Flutter Development. Flutter is used for building cross- platform applications.

1. **Version Control:**

Version control software like Git and platforms like GitHub or GitLab for collaborative development and code management.

**Hardware Requirements:**

1. **IoT Sensors:**

Soil moisture sensors to measure soil moisture content.

Temperature sensors to monitor soil temperature.

PH sensors for soil pH level measurements.

Nutrient level sensors for assessing soil nutrient content.

1. **IoT Communication Hardware:**

Microcontrollers or single-board computers like Arduino, Raspberry Pi, or ESP8266/ESP32 for interfacing with and transmitting data from the sensors.

Wireless communication modules (e.g., Wi-Fi or LoRa) for connecting IoT devices to the internet and transmitting data.

1. **User Interface Device:**

Devices such as computers, tablets, or smartphones for accessing the user interface.

1. **Field Equipment:**

Equipment for deploying sensors in agricultural fields, including weatherproof casings, mounting hardware, and wiring.

1. **Optional Hardware (for Additional Features):**

GPS modules for geolocation data.

Cameras or imaging devices for image-based soil analysis (if applicable).

Weather stations for collecting weather data to supplement soil analysis.

**EXPECTED OUTCOME -**

1. **Enhanced Soil Health Assessment:**

Accurate real-time monitoring of soil moisture, temperature, pH, and nutrient levels, leading to improved soil health assessment for organic farming.

1. **Optimized Organic Fertilizer Application:**

Precise recommendations for organic fertilizer application based on real-time data, reducing overuse and minimizing environmental impact.

1. **Reduced Chemical Dependency:**

Decreased reliance on chemical pesticides and fertilizers due to early pest detection and organic nutrient management, aligning with organic farming principles.

1. **Crop Yield Improvement:**

Increased crop yields through data-driven decisions on irrigation, nutrient application, and pest management in organic farming.

1. **Improved Organic Certification Compliance:**

Support for organic farmers in maintaining and documenting compliance with organic certification standards, facilitating the certification process.

1. **Sustainable Soil Management:**

Long-term soil health improvement through data-driven insights, promoting sustainable and regenerative farming practices.

1. **User-Friendly Interface:**

User-friendly web and mobile interfaces for farmers to easily access soil health information and receive actionable recommendations.

1. **Increased Adoption of Organic Farming:**

The project's success may lead to increased interest and adoption of organic farming practices among farmers, contributing to the growth of the organic farming sector.

1. **Data-Driven Decision-Making:**

Encouragement of data-driven decision-making in agriculture, improving overall farm management and productivity.

These precise expected outcomes reflect the project's potential to make a meaningful impact on organic farming by leveraging IoT and machine learning technologies for soil nutrition management. They emphasize benefits such as improved soil health, resource conservation, reduced chemical usage, and increased organic certification compliance, which are all key objectives for sustainable and organic agriculture.