# HARNESSING EMBEDDED TECHNOLOGY FOR SMART TOBACCO AGRICULTURE WITH ARBUSCULAR MYCORRHIZAL FUNGI AND ORGANIC FERTILIZERS.

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## FINAL YEAR DESIGN PROJECT REPORT

This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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## APPROVAL

This Project titled **"Harnessing Embedded Technology For Smart Tobacco Agriculture with Arbuscular Mycorrhizal Fungi and Organic Fertilizers"**, submitted by **Raisa Ferdoush** and **Mohammad Nurul Afsar Ikram** to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on **15-07-2024**.

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We hereby declare that this project has been done by us under the supervision of **Dr. Fizar Ahmed, Associate Professor, Department of Computer Science and Engineering, Daffodil International University**. We also declare that neither this project nor any part of this project has been submitted elsewhere for the award of any degree or diploma.

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# ABSTRACT

The research titled “Harnessing Embedded Technology For Smart Tobacco Agriculture With Arbuscular Mycorrhizal Fungi and Organic Fertilizers” show the important insights about embedded technology based Smart Agriculture for Tobacco cultivation. Tobacco cultivation need high level nutrients for its plant growth and also tobacco cultivation on land create soil degradation problem. As a result, we can’t cultivate tobacco on same land again and again. To mitigate this problem our finding’s is that we use Arbuscular Mycorrhizal Fungi (AMF) to uptake important soil nutrients like phosphorus, Potassium etc. Using 3 pin Npk sensor we collect Nitrogen, phosphorus and potassium level on soil. Based on Phosphorus optimal value, AMF mixed soil has appropriate phosphorus level as compare to Non-AMF mixed soil. Gathering data from two type of data sources we labeled AMF mixed soil as “Satisfactory” and Non-AMF mixed soil as “Unsatisfactory”. Our dataset consists of 8314 datapoints. After Preprocess our dataset we apply five machine learning algorithm which are as follows: Gradient Boosting, Random Forest, SVM, Decision-Tree, and Naïve Bayes. Among all models SVM and Decision has lowest accuracy 85%. Gradient Boosting outperformed all other model with accuracy 87% which was highest accuracy. Our work will help farmers to classify their soil quality which was suitable for their tobacco cultivation. This will reduce the use of Chemical fertilizers on soil.

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## LIST OF ACRONYMS

| | |
|---|---|
| AMF | Arbuscular Mycorrhizal Fungi |
| SVM | Support Vector Machine |
| ML | Machine Learning |
| IoT | Internet of Things |

# CHAPTER 1
# Introduction

## 1.1. Overview

This study investigates that embedded technology may transform smart tobacco farming by encouraging environmentally friendly methods and raising crop yield. In order to provide optimal monitoring and control, the research looks into the synergistic effects of organic fertilizers and Arbuscular Mycorrhizal Fungi (AMF) on tobacco plant growth. By using AMF into soil, we can improve soil structure. As we know, tobacco cultivated land has Soil degradation problem. In that case, AMF can uptake the soil nutrient. NPK sensor helps us to get Nitrogen, phosphorus and Potassium value. Based on these values we can compare the soil quality before and after adding AMF into the soil.

## 1.2. Background and Present State

In earlier times, farmers would assess soil suitability and select crops based on their own senses and beliefs, without regarded for humidity, water levels or climate condition. The use of chemical fertilizer is based on suspicions, which could potentially impact production if incorrectly applied. IOT technology utilize agriculture parameter as IoT is extended with sensors and actuators. There are many sensors like Humidity sensor, water sensor, temperature sensor, Moisture sensor etc. Remote sensor frameworks can be used to utilize precision agriculture [1]. Bangladesh has significant environmental impact of tobacco farming. Despite the implementation of tobacco control measures across the country but insufficient monitoring and implementation have resulted in notable environmental deterioration and public health issues [2]. WHO The FCTC's tobacco control strategy focuses earlier disputes between tobacco manufacturers and farmers, implying that long term alliances and local infrastructure investments are critical for successful tobacco control in developing nations [3].

Overcoming the increasing difficulties in farming requires an understanding of the diverse agricultural ecosystem. By leveraging modern digital technologies both farmers and companies can increase production. Modern digital technology that constantly monitor the physical environment and generate massive amounts of data which can helps to take better decisions on agriculture [4]. Taking the next step in agriculture involves proposing Internet of Things technologies to monitor numerous metrics for greater precision farming. This technology gives useful information about plant growth, agricultural diseases, and soil qualities, which benefits crops [5]. Tobacco production in Bangladesh has a huge environmental impact, influencing soil, water, and air quality. Tobacco cultivation losses soil fertility [6]. Arbuscular Mycorrhizal Fungi (AMF) has been suggested for sustainable agriculture, although their performance in field soils with native AMF is little understood. AMF inoculation can improve soil nutrient uptake and plant growth in a variety of field soil situation [7].

### 1.3. Problem Statement

Tobacco agriculture has immense obstacles in maintaining sustainable farming methods while increasing yield and quality. Traditional tobacco cultivation methods frequently include chemical fertilizers and pesticides, which can contribute to soil degradation, environmental contamination, and increased production costs. It disrupts the long-term viability of tobacco production. Our aim is to proposed IoT based smart agriculture to enhance tobacco cultivation though AMF and Organic Fertilizer. Including the AMF on soil can enhancing soil fertility, improving plant health, and reducing dependency on chemical inputs. By leveraging Machine learning techniques on NPK dataset, which is collected from NPK sensor we can classify good quality of soil to enhance tobacco cultivation. Integrate AMF inoculation we can enhance soil quality.

### 1.4. Objectives

Our primary objective is to compare soil quality before and after the application of arbuscular mycorrhizal fungi (AMF). AMF inoculation in the soil can mitigate soil degradation, allowing for the continuous cultivation of tobacco on the same land. By evaluating these factors, we can gain insights into soil conditions. Instead of relying on chemical inputs to enhance soil quality, we can utilize AMF and organic fertilizers to develop a smart agricultural system for tobacco cultivation, which offers significant environmental benefits.

### 1.5. Scope and Limitations

The present research aims to create and implement an IoT-based smart agriculture system for tobacco growing. The study was carried out in an embedded laboratory to assess the impact of organic fertilizers and arbuscular mycorrhizal fungi (AMF) on soil fertility, plant health, and crop output. Machine learning algorithms will be used to classify soil quality based on NPK sensor data. Furthermore, the study looks into the use of AMF inoculation to improve soil quality and reduce reliance for chemical inputs. The goal of this research is to give a full review of how these technologies and AMF can improve tobacco agriculture's sustainability and production.

The IoT based system's scalability to bigger agricultural settings potential barriers, and the accuracy of data from NPK sensors may have an impact on the reliability of machine learning models. Furthermore, the economic feasibility of introducing these technologies for farmers must be examined. While the study intends to identify soil conditions before and after adding AMF and predict soil quality using NPK data, it doesn't include the creation of a comprehensive application or system for practical usages. Additionally, many farmers may lack the expertise and abilities to gather and understand soil data from Npk sensors, therefore limiting the practical application and adoption of the suggested.

### 1.6. Report Organization

The proposed report is structured with a comprehensive layout to guide readers through the research process, findings, and implications. Each chapter serves a specific purpose, contributing to the overall coherence and depth of the document.

**Chapter 1: Introduction**

The introductory chapter sets the stage for the research, providing a background on the smart agriculture, the function of embedded technology, and the application of organic fertilizers and Arbuscular Mycorrhizal Fungi (AMF) in tobacco cultivation. Impact of tobacco cultivation. It provides an overview of the study's goals, research question, and General framework.

**Chapter 2: Literature review**

The literature review chapter looks extensively over relevant literature and earlier research. This section provides an extensive understanding of the theoretical foundations, techniques, and technological breakthroughs pertaining to smart agriculture, embedded technology, AMF, and organic fertilizers. It provides background for the current investigation and identifies gaps in existing knowledge.

**Chapter 3: Methodology/ Requirement Analysis & Design Specification**

The research methods chapter describes the approach used to conduct the study. It explains the research strategy, data gathering methods, and reasoning for selecting specific methodologies. This chapter also examines the methodology used to assess the efficacy of embedded technology in managing AMF and organic fertilizers, as well as ethical considerations and potential limits to the study.

**Chapter 4: Implementation**

This chapter describes the research's practical execution. It outlines how embedded technology is used in tobacco cultivation, including the use of AMF and organic fertilizers, as well as the monitoring and data collection processes.

**Chapter 5: Result and Analysis**

This chapter presents and analyzes the study's findings. This involves an evaluation of how embedded technology affects the efficiency and precision of AMF and organic fertilizer application, plant health, yield, and overall sustainability. Comparative assessments of various embedded technology solutions and their efficacy are also covered.

**Chapter 6: Impact on Society, Environment and Sustainability**

This chapter considers the research findings' broader implications for society, the environment, and sustainability. It examines how combining embedded technology with AMF and organic fertilizers can result in more sustainable agriculture practices, better resource utilization, and improved crop management. The possible benefits to farmers, the agricultural industry, and the environment are discussed.

**Chapter 7: Conclusion and Future work**

The last chapter highlights the important findings of the study, evaluates its limits, and makes recommendations for future research and practical applications. It emphasizes the importance of the study in improving smart tobacco cultivation and recommends strategies to improve the use of embedded technology, AMF, and organic fertilizers in farming.

## 1.7. Summary

This chapter describes our research on improving smart tobacco agriculture using embedded technology, arbuscular mycorrhizal fungus (AMF), and organic fertilizers. We discuss the need of sustainable approaches in tobacco cultivation, stressing the problems with old methods. The issue statement focuses on how to improve soil quality without using chemicals. Our goals include assessing soil conditions before and after AMF application and creating a smart agriculture system. The scope and restrictions determine the study bounds, while the report organization gives a structural overview of the work.

# CHAPTER 2
# Literature Review

## 2.1 Overview

This section encompasses the existing literature on the use of sophisticated sensors technology, notably NPK sensors, in conjunction with arbuscular mycorrhizal fungus (AMF) and organic fertilizers in sustainable agriculture. The combination of these technologies is intended to improve soil quality, optimize fertilizer management, and increase crop yields in tobacco growing. The review provides a complete overview of prior studies, highlights gaps in current understanding, and establishes the context for the current research.

## 2.2 Related Works

Sneha et al. (2023) present methods and technologies for assessing soil nitrogen, phosphorus, and potassium (NPK) concentration in order to increase crop output. It emphasizes the use of NPK sensors for on-the-go detection, which eliminates the need for typical, expensive lab tests. With the advent of IoT in agriculture, there is a greater demand for tiny, low-power, and quick sensors. Furthermore, machine learning techniques improve soil NPK levels by correctly forecasting nutrient concentrations from sensor data. This review is to help guide the development of effective soil NPK detection sensors [8]. The study discovered that inoculated onion plants benefited the most from moderate fertilizer levels (60-30-50 kg ha-1 NPK), which improved their growth and nutrient uptake. In contrast, greater fertilizer levels lowered the efficiency of AMF, resulting in decreased growth and nutrient levels in inoculated plants. Plants that were not infected benefited from increasing fertilizer levels. As a result, the researchers suggest that employing AMF with moderate fertilizer levels can promote plant growth and nutrient absorption, minimizing the requirement for excessive chemical fertilizers in onion farming [9]. This study examined into using mycorrhizae, Bacillus subtilis, and Pseudomonas fluorescence to suppress Sclerotium rolfsii in common beans and improve plant nutrition. Bio-agent inoculations greatly boosted plant defense enzyme activity with low phosphorus (P) inputs, especially in combination treatments. Field experiments revealed that AMF inoculation increased straw and green pod yields, as well as P and Fe uptake, as compared to non-inoculated plants, with mixed inoculants producing even greater increases. This demonstrates that bio-treatments can efficiently minimize soil pollution from fertilizers and pesticides [10].

### 2.3 Comparison between existing works

A comparative examination of comparable works highlights methodology and strengths for the current research landscape. The table below summarizes the Comparison between Related work.

Table 2.3.1: Comparison between existing works

| Study | Focus | Key Findings | Strength | Implications |
|---|---|---|---|---|
| Basiru et al. [11] | Mycorrhizal-based inoculants in agriculture. | 90% solid formula; predominant AMF species detected; 47% soil application. | Comprehensive product overview | Research on AMF and other bacteria is necessary to improve agricultural productivity and soil health. |
| Akbar et al. [12] | Native mycorrhizal species on wheat | Higher nutrient content in grain products increased tillers, biomass, grain yield, and soil fertility. | efficient in raising soil fertility and wheat production | decreased dependence on artificial fertilizers; enhanced soil health and crop quality |
| Messa et al. [13] | AMF in stress management and yield | Rhizobacteria and AMF boost yields while reducing stress. | Highlights importance of biotechnologies. | Enhanced sustainability and productivity; less environmental impact. |

## 2.4 Open Issues

Even with the encouraging outcomes, there are still a few unresolved problems. More thorough research is required to fully understand how NPK sensors, AMF, and organic fertilizers work together in various crops and soil conditions. The broad deployment of NPK sensor technology is hindered by its high initial cost and technical complexity. Long-term research is also necessary to confirm how these practices together affect crop output and soil health. Closing these gaps will be essential to creating agricultural systems that are both workable and sustainable.

## 2.5 Summary

The literature on the application of organic fertilizers, AMF, and NPK sensors in agriculture has been reviewed in this chapter. The review emphasizes the advantages of each of these technologies and techniques separately as well as their potential for combined synergy. It also points forth a number of shortcomings and difficulties that require more investigation. This establishes the framework for our research, which attempts to investigate the combined use of these elements to create an intelligent and long-lasting tobacco farming system.

# Chapter 3
# Methodology/ Requirement & Design Specification

## 3.1 Overview

This chapter examines the technique and design specifications required for the effective implementation of the research project titled "Harnessing Embedded Technology for Smart Tobacco Agriculture with Arbuscular Mycorrhizal Fungi and Organic Fertilizers." The goal of this research is to improve soil health and crop productivity by combining modern sensor technology, notably NPK sensors, with sustainable agriculture methods. By attentively describing the methodology and design requirements, this chapter strives to establish a comprehensive framework for the research project's execution and administration. It guarantees that all required components and processes are explicitly specified, allowing for a disciplined and systematic approach to attaining the project's objectives.

## 3.2 Proposed Methodology/ System Design

As we know, tobacco cultivation causes soil degradation as it has different soil nutrients uptake pattern. To fulfil its optimal growth and leaf production, requiring substantial amount of Nitrogen, Phosphorus and Potassium (NPK). Kutub et al. (2015) discuss that Tobacco farming in Kushtia, which has been promoted since freedom, is significantly chemically intensive and has a negative impact on biodiversity, soil fertility and water quality. Excessive agrochemical usage pollutes soil and water, decreases pH, depletes oxygen in water, and harms local flora and wildlife, aggravating environmental deterioration [14]. Excessive use of Chemical fertilizer has been used to uptake Phosphorus value. Phosphorus (P) has a direct relationship with the root zone since it is essential for root development and function. Reichert et al. (2019) discuss that maintaining high nutrient levels in the root growth zone is critical for tobacco crop nutrition and may be increased for better tobacco cultivation results [15]. AMF inoculation significantly enhanced the essential oil yield and the uptake of nitrogen, phosphorus, and potassium [16]. Optimal Range for Phosphorus is 50 ppm or higher and Potassium is (150-300) ppm [17].

Our proposed method is gathering NPK data from 3-pin NPK sensor to quantify NPK levels in soil samples, comparing soils that have been treated with Arbuscular Mycorrhizal Fungi (AMF) and those that have not. Based on phosphorus levels, we classify non-treated or low-phosphorus soils as "Unsatisfactory" and AMF-treated soils as "Satisfactory." After combining these labeled datasets, we have a merged dataset with two classes: "Satisfactory" and "Unsatisfactory". After preprocessing the Final dataset, we apply multiple classification techniques on this information to estimate soil quality. This method allows us to evaluate the efficacy of AMF treatment in boosting phosphorus levels, preparing the soil for tobacco growing, and maintaining optimal soil health.

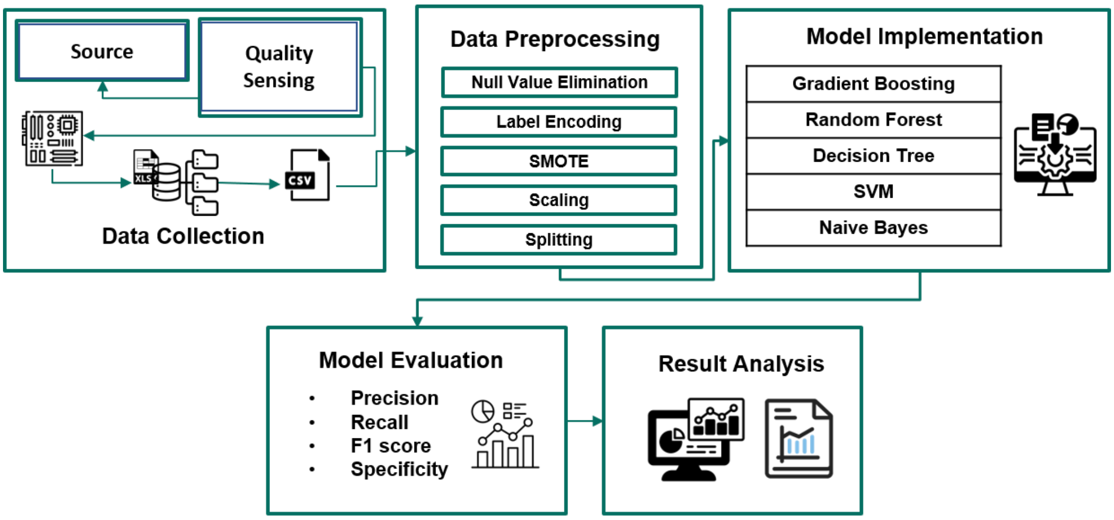


Figure 3.2.1: Proposed Methodology

**IoT device Prototype:** A preliminary version of an Internet of Things system that is intended to monitor and administer smart tobacco agriculture is referred to as an IoT prototype. For the purpose of collecting, transmitting, and analyzing NPK data, this prototype typically comprises communication modules, microcontrollers (such as Arduino), and sensors (such as NPK sensors). The objective is to evaluate and enhance the integration of sustainable agricultural practices with embedded technology prior to its full-scale implementation.

Figure 3.2.2: IoT device Prototype

**Circuit Diagram:**

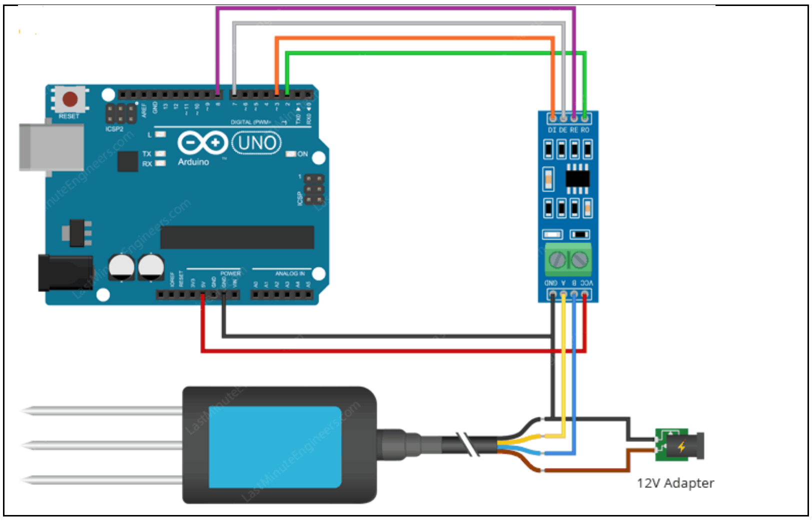


Figure 3.2.3: Circuit Diagram

**Data Sources:** We have collected the data from Soil. There are two main source one is AMF mixed soil and another is Normal soil without AMF mixing on it.

|  |  |
|---|---|
| Before AMF mixing on Soil | After AMF mixing on Soil |

Figure 3.2.4: Data Sources

**AMF Source:** As we know AMF stands for Arbuscular Mycorrhizal Fungi. It increased Phosphorus value movement. Uptake P value from soil is necessary to reduce chemical fertilizer and fulfill the requirements of Tobacco cultivation.

Figure 3.2.5: AMF Source

**Data Collection Process:** As we are working on IoT based agricultural research, our data collection has two phases. In phase-1, Before adding AMF (Arbuscular Microzaya Fungi) on soil we collect the NPK value through a 3 pin Npk sensor which is an IoT device. In phase-2, we add AMF (Arbuscular Microzaya Fungi) into the soil and collect the Npk value through the Npk sensor. After adding AMF into the soil, we see that the phosphorus value movement increase compares to phase-1 Phosphorus value. Based on two phases, we merged our dataset to classify the soil quality by considering Phosphorus value movement. We are performing Binary classification and two classes are Satisfactory and Unsatisfactory.

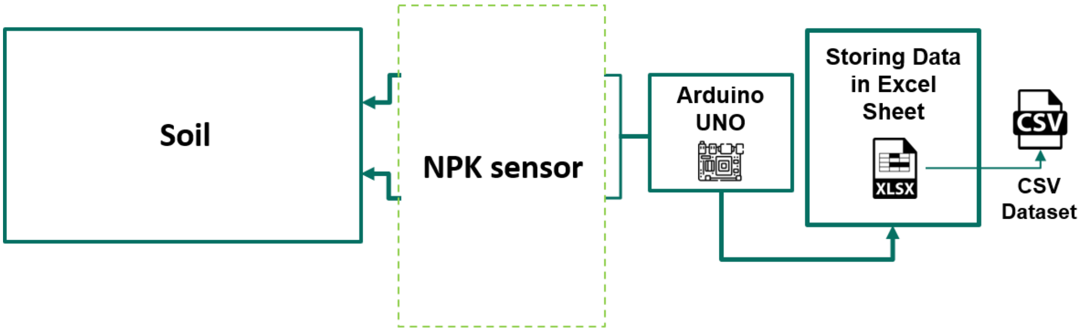


Figure3.2.6: Data Collection Process

**Dataset Description:** As we mentioned above that phase-1 data collection, we get data from Non-AMF mixing soil. In Phase-2 data collection, we get data from AMF mixing soil. We labeled Non-AMF mixing soil as "Unsatisfactory" and AMF mixing soil as "Satisfactory". Finally, we merged both phase-1 and phase-2 dataset to get our final dataset to feed into machine learning models.

Table 3.2.1: Overview of Final Dataset

| **Timestamp** | **Nitrogen** | **Phosphorus** | **Potassium** | **Binary_class** |
|---|---|---|---|---|
| 2023-12-27T06:47:54+00:00 | 193 | 77 | 218 | Satisfactory |
| 2024-03-04T10:24:28+00:00 | 100 | 32 | 129 | Unsatisfactory |
| 2023-12-26T16:26:19+00:00 | 166 | 81 | 225 | Satisfactory |

## 3.3 Hardware/ Software Requirement

### 3.3.1 Hardware Requirements

As it is our IoT based smart Agricultural research, Hardware requirements are basically meaning IoT devices.

**1)** Arduino UNO R3: The Arduino Uno R3 is a popular microcontroller board known for its versatility, simplicity, and robustness in a wide range of applications. Built around the Atmega328P microcontroller, it has 14 digital input/output pins, 6 of which support PWM capabilities, as well as 6 analogue input pins, allowing for smooth interfacing with a variety of sensors and peripherals. With USB programming and power connectivity, as well as compatibility with a wide range of shields and sensors, the Uno R3 provides an accessible platform for both beginners and specialists to construct new projects ranging from basic LED control to sophisticated IoT solutions. Its modest form factor, combined with the rich Arduino environment, which includes libraries, tutorials, and an active community, renders it an indispensable tool in the world of embedded systems. The Arduino Uno R3 can be powered by an external power source or a USB connection. It operates best with input voltages between 7 and 20 volts, however 7 to 12 volts is the suggested range. 32 KB of flash memory, 2 KB of SRAM, and 1 KB of EEPROM are available on the ATmega328P microcontroller for storing code and non-volatile data, respectively. The board has an integrated USB-to-serial converter for connectivity, making it simple to communicate with a computer for data exchange and programming. For firmware reprogramming, it also has a 6-pin ICSP (In-Circuit Serial Programming) header.


Figure 3.3.1.1: Arduino Uno R3

2) **NPK Sensor:** The NPK sensor monitors electrical conductivity, which is correlated with each nutrient's concentration, by sticking its probes into the soil. A microcontroller's analog input ports can read the analog voltage output that the sensor produces, which is well-adjusted to the nutrient levels. Researchers can obtain important knowledge about the fertility and health of the soil by regularly measuring the NPK levels of the soil. This information helps the researchers make judgments about crop management and fertilization. The 3-pin design's ease of use guarantees that connecting the sensor to data collecting systems is simple. For example, seamless data collection and processing can be achieved by connecting the SIG pin to an analog input pin and the VCC and GND pins to the corresponding power and ground lines of an Arduino board. The 3-pin NPK sensor's simplicity of use makes it a priceless instrument for field and laboratory settings, greatly advancing the fields of agricultural and environmental sciences.


Figure 3.3.1.2: Arduino Uno R3

**3.3.2** Software Requirement

Enabling IoT sensor to sense soil NPK value, gather Npk value into excel, applying machine learning to collected data require lot of software requirement.

1) **Arduino IDE:** The Arduino IDE (Integrated Development Environment) is an open-source platform for programming, compiling, and uploading code to Arduino boards. It includes a code editor with syntax highlighting, a library manager for adding functionality, and a serial monitor for real-time debugging and communication with attached hardware. This environment enables seamless interaction with sensors, such as the NPK sensor, allowing for optimal data collection and display. The Arduino IDE (Integrated Development Environment) is an open-source platform for programming, compiling, and uploading code to Arduino boards. It includes a code editor with syntax highlighting, a library manager for adding functionality, and a serial monitor for real-time debugging and communication with attached hardware. This environment enables seamless interaction with sensors, such as the NPK sensor, allowing for optimal data collection and display.

2) **Microsoft Excel:** Data from the NPK sensor is captured and stored in Microsoft excel for easy analysis and visualization. Excel contains extensive features for organizing, charting, and interpreting sensor data to support research findings.

3) **Google Collab:** It is a free cloud-based platform which has limited Compiling that enables users to develop and execute Python code within a Jupyter notebook environment. It provides significant computing resources, like as GPU and TPU support, making it excellent for data analysis, machine learning,

and deep learning workloads is provided by Google colab. We use Google colab to apply machine learning algorithms to the NPK sensor data.

### 3.4 Project Management and Financial Analysis

Effective project management is necessary for the successful implementation of Iot based smart tobacco cultivation. The following are important components of the management process:

● Project planning: Set the goals, parameters, deliverables, and schedule for the project. Make a project team with the proper roles and duties, identify the project's stakeholders, and allot resources.

● Risk Assessment: Determine possible potential risks and create plans for mitigating them. Consider the risks associated with model accuracy, data availability, technical difficulties, and regulatory compliance. Also, we have to sure about financial risk management to mitigate it.

Here we illustrative financial analysis of our IoT based research for Final Year Design Project (FYDP).

Table 3.4.1: Financial Analysis

| S. N | Components | Estimated Cost |
|---|---|---|
| 1 | Tools and Equipment (NPK Sensor, Soil Box) | 18,000-20,000/- BDT |
| 2 | Power Supply Unit, Battery Backup, Solar Power System. | 4000-6000/- BDT |
| 3 | Documentation and Report Writing. | 500-1,000/- BDT |
| 4 | Equipment Failure, Data Loss, Budget Overruns. | 2000-3000/- BDT |

### 3.5 Summary

Here, we have discussed about our proposed approach. We applying AMF on soil to see that if phosphorus level can upgrade or not. If this is not happen we have to use chemical or Organic fertilizers on it. As Phosphorus is necessary for root level improvement in tobacco cultivation. Our study consists of soil preparation, AMF inoculation, organic fertilizer application, and continual monitoring with NPK sensors. We also talk about hardware and software requirements for the project have, as well as it will help us to make financial analysis.

# Chapter 4
# Implementation

## 4.1 Overview

In this section, we will discuss how we will implement our proposed methodology, preprocess dataset to put on machine learning model. Our output will be binary classification on soil quality to know that if the soil is suitable or not suitable for the tobacco cultivation. To get our result we have to train/test our model. Implementing machine learning model then we will evaluate our model to see the performance on binary classification. All the above-mentioned work will be done in this present chapter.

## 4.2 Train Model/Prototype Design

In this section, we will discuss Data preprocessing technique and Machine learning algorithm which is appropriate for Binary classification to predict soil quality. After completing this, we will Train our selected machine learning model.

**Data preprocessing:**

There are 8318 rows × 5 columns in our dataset. In this step we have applied five preprocessing steps into our dataset to change the data set as required for research requirements.

1) **Null value elimination:** It refers to the process of removing an entire row from a dataset where one or more values are missing. This ensures that each row in the dataset contains complete information. In our dataset there are 4 null values found row wise. We have applied the dropna() function to eliminate the null values. We also drop our Timestamp column as its not necessary for our Final dataset.
2) **Label Encoding:** In this technique categorical data can be converted into numerical data [18]. In this process we have changed our label column as it was labeled in two classes named Satisfactory, and Unsatisfactory. By importing Label Encoder, we have changed our label column values in numerical data which are 0,1.
3) **SMOTE:** This technique is applied in imbalanced data so that the dataset helps to give balance class distribution. We have applied the SMOTE technique to our label column to balance the data set.

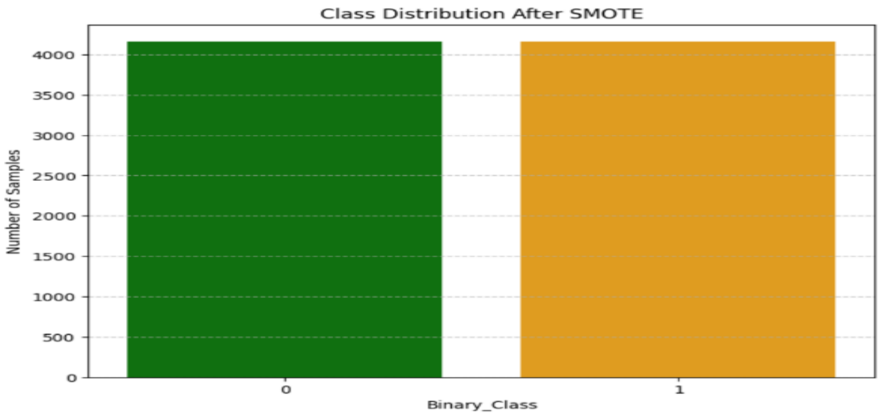


Figure 4.2.1: SMOTE Technique

4) **Scaling (Standard Scaler):** It is a class from sklearn.preprocessing module and creates an instance which can be used to standardize features by subtracting the mean and dividing the standard deviation.
5) **Splitting:** To test the model we have to first divide the feature set into train set and test set here we have also applied this process. We have split the dataset into training, testing and validation. Training 80%, Testing 10% and validation 10%.

**Model Implementation:** In our large dataset we have used five machine learning algorithms like Gradient Boosting, Random Forest, Naive Bayes, SVM, Decision Tree to classify or predict the category of the soil quality perfectly. After dividing the data set into a training and testing set, we have implemented these models to get best accuracy.

1) **Gradient Boosting:** Gradient boosting is a collective learning strategy that promotes robustness by combining the predictive strength of many base estimations. In order to generate accurate prediction from massive quantities of data, Gradient boosting algorithm techniques are implemented.
2) **Random Forest:** This technique employs ensemble learning to perform classification and regression. It generates a collection of decision trees using a bagging approach and a random subset of data. The final decision trees are constructed by combining the outputs of every decision tree in the random forest.
3) **Naive Bayes:** The Naive Bayes algorithm is a supervised learning method that applies Bayes theorem to solve classification issues. It is mostly used in text classification, with a high dimensional training set. It is a probabilistic classifier, which implies that it makes predictions based on the likelihood of an item.
4) **Support Vector Machine (SVM):** It is a supervised machine learning algorithm that is used in classification and regression tasks. Support Vector

Machines determine the hyperplane that optimally divides data points into classes while maximizing the margin between classes, with support vectors controlling the hyperplane's position. SVM are successful for both linearly and nonlinearly separable data, with kernel functions.

5) **Decision Tree:** The decision tree approach approximates a discrete valued target function using a decision tree representation. A decision tree sorts instances from root to leaf nodes based on feature values. Each nodes indicated a choice on an attribute of the instance, whereas each branch provides a potential value for that feature.

### 4.3 System Testing/ Model Evaluation

We have used evaluation metrics to determine the effectiveness of machine learning models. These are qualifiers that determine if the output is valid. They consist of two parts: True/False and Positive/Negative. The first portion represents the output's accuracy, while the second part might represent the classification's label value.

**Accuracy:** The calculation of accuracy involves dividing the entire number of data sets (P + N) by the sum of two accurate predictions (TP + TN). The accuracy ranges from 0.00 to 1.0 at its worst.

$$\text{Accuracy} = (TP + TN) \div (P + N) \qquad (1)$$

**Specificity:** The specificity of a classifier is the ratio of how much was accurately labeled as negative to how much was truly negative. It is used in places with a high priority for negative categorization.

$$\text{Specificity} = TN \div (FP + TN) \qquad (2)$$

**Precision:** The precision metric determines the quality of positive predictions by measuring their correctness. It is the number of true positive outcomes divided by the sum of true positive and false positive predictions.

$$\text{Precision} = TP \div (TP + FP) \qquad (3)$$

**Recall :** Recall, also called sensitivity, measures the model's ability to detect positive events correctly. It is the percentage of accurately predicted positive events out of all actual positive events.

$$\text{Recall} = TP \div (TP + FN) \qquad (4)$$

**F1 Score:** The F1 score or F-measure is described as the harmonic mean of the precision and recall of a classification model. The two metrics contribute equally to the score, ensuring that the F1 metric correctly indicates the reliability of a model. The F1 score is a fundamental metric for evaluating classification models and understanding how this metric works is crucial to ensure your classification model's performance.

$$\text{F1 Score} = 2 \times [(\text{Precision} \times \text{Recall}) \div (\text{Precision} + \text{Recall})] \qquad (5)$$

To sum up, these measurements have been crucial in helping us get good results from our evaluation procedure. They have given us insightful information on how well our machine learning models are doing, allowing us to make wise choices and optimize for superior outcomes.

Table 4.3.1: Evaluation of All Models

| **Algorithms** | **Accuracy** | **Precision** | **Recall** | **F1 score** | **Specificity** |
|---|---|---|---|---|---|
| Gradient Boosting | 87% | 0.87 | 0.87 | 0.87 | 0.88 |
| Random Forest | 86% | 0.86 | 0.86 | 0.86 | 0.86 |
| Naïve Bayes | 86% | 0.86 | 0.86 | 0.86 | 0.85 |
| SVM | 85% | 0.85 | 0.85 | 0.85 | 0.85 |
| Decision Tree | 85% | 0.85 | 0.85 | 0.85 | 0.84 |

### 4.4 Summary

In this phase, we implement machine learning algorithm. We train and test our models. Using measurements like Precision, Recall, F1 score and Specificity we evaluate our five-machine learning model. Above table 4. shows that all the algorithms performed quite well with high accuracy and precision. Gradient Boosting algorithms achieved an accuracy of 87% with perfect precision, recall, F1 score and specificity of 0.88.

# Chapter 5

# Result and Analysis

## 5.1 Overview

In this present section, we will discuss about result base on accuracy and also analysis it based on cross validation, confusion matrix performance.

## 5.2 Experimental/ Simulation Result

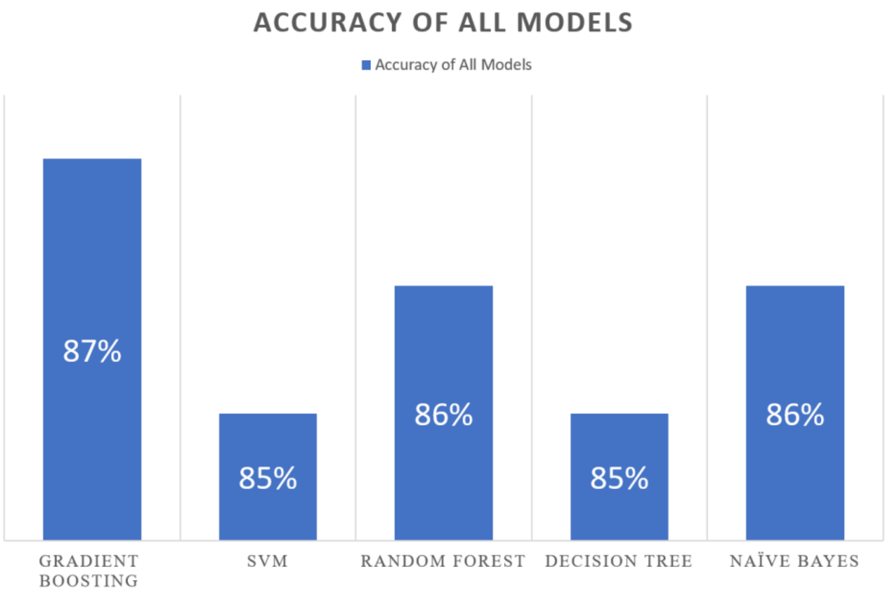


Figure 5.2.1: Accuracy of All models

Figure 5.2.1. shows the performance of algorithms based on their accuracy scores. Gradient Boosting, Random forest, Decision Tree algorithms all exhibit identical accuracy ratings are 87%, 86% and 85%. This consistency underscores the robustness and reliability of these algorithms in accurately predicting outcomes. The SVM algorithm showed an accuracy of 85%. On the other hand, the Naive Bayes algorithm and Random Forest algorithm has the same accuracy rate of 86%. Overall, it shows high performance levels of the evaluated algorithms, emphasizing their efficacy in handling the dataset.

## 5.3 Performance/ Comparative Analysis

To understand how well our model is train , we have to check cross validation and confusion matrix. If our models has no underfitting and overfitting issue then evaluation of all models and accuracy of cross validation will remain close.

**Cross Validation:**

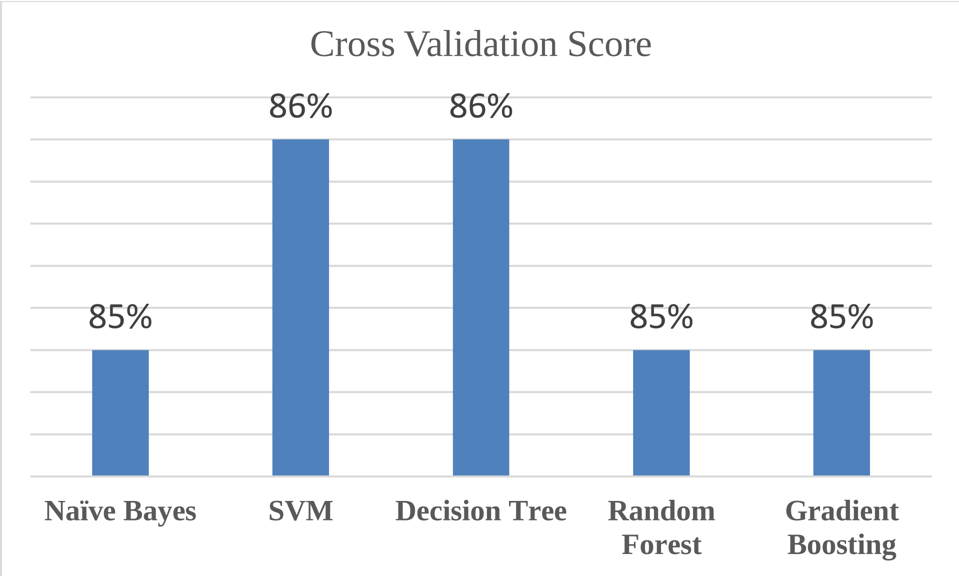


Figure 5.3.1: Cross Validation Score of All Algorithms

Figure 5.3.1. shows the cross-validation score of all algorithms. Cross validation score refers to a method to evaluate the performance of a machine learning model by repeatedly splitting the dataset into training and testing sets to ensure reliable assessment and generalization to new data. We have applied the K-fold cross-validation technique, which is used to evaluate the performance of machine learning models by splitting the dataset into k subsets. In our research here, k= 5 so the model is trained and tested 5 times, using 5 different subsets for testing each time. Here SVM and Decision tree algorithms show high performance with scores of 86% and 86%, respectively. Naïve Bayes, Random forest and Gradient boosting follows same score of 85%.

**Confusion Matrix:**

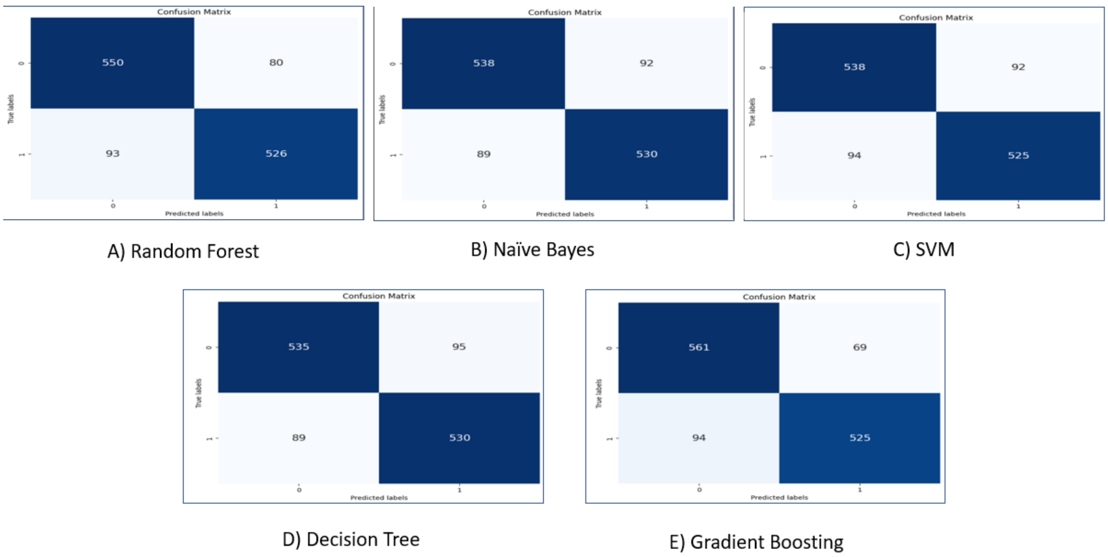


Figure 5.3.2: Confusion Matrix of All Models

### 5.4 Summary

In present section , we discuss accuracy of all model. Then compare accuracy of all model and Cross validation of all models to see if there is any overfitting or underfitting issue remain or not.  The model performance was so good. By completing comparative analysis we know all about our five models.

# Chapter 6

# Impact on Society, Environment and Sustainability

## 6.1 Impact on Life

Arbuscular mycorrhizal fungus (AMF), organic fertilizers, and integrated technology can greatly improve smart tobacco agriculture's financial returns, environmental sustainability, and agricultural output. Higher agricultural yields and decreased production costs are both made possible by embedded technology, which also allows for precise monitoring and effective resource management. Agricultural resilience and sustainability in the face of climate change are enhanced by the use of organic and AMF fertilizer’s, which improve soil health, decrease chemical use, and promote biodiversity. In addition to empowering the local population and offering new job opportunities, this method promotes healthier products, boosts market prospects, and supports rural economic growth. The tobacco industry may improve its efficiency, longevity, and bottom line by adopting these cutting-edge practices.

## 6.2 Impact on Society & Environment

Social change may result from the application of organic fertilizers, integrated electronics, and arbuscular mycorrhizal fungus in smart tobacco farming. Through the reduction of the demand for chemical fertilizers, these technologies promote sustainable agricultural methods and enhance soil health. Should this modification lead to higher-quality tobacco and bigger crop yields, farmers might make money. Environmental sustainability is promoted by it in terms of ecology by reducing agricultural pollution and increasing biodiversity. Moreover, these advancements can help with rural development, enhance living conditions, and boost international initiatives to adopt ecologically friendly farming practices. Combined, these initiatives enhance agricultural results and support a more prosperous, just, and sustainable agriculture sector.

Through higher crop resilience, better soil health, and less pollution, the use of organic fertilizers, embedded technology, and arbuscular mycorrhizal fungi (AMF) in smart tobacco agriculture benefits society. By lowering the demand for synthetic pesticides and fertilizers, these techniques protect aquatic and groundwater ecosystems. More organic material also aids in the sequestration of carbon, which slows down global warming and promotes sustainable agriculture.

## 6.3 Ethical Aspects

Embedding technology in organic fertilizers and arbuscular mycorrhizal fungus (AMF) for smart tobacco growing has serious ethical ramifications. Environmentally speaking, these techniques show a commitment to protect natural resources by promoting sustainability and biodiversity preservation. Economically speaking, they believe in fair income for farmers and reduce costs to that end. They lessen the exposure to dangerous substances that farmers and consumers have to deal with health-wise. It takes respecting privacy and using suitable data management to uphold accountability and transparency in the use of technology. Activities meant to empower farmers via training and education strengthen the resilience and independence of the community. These steps comply with the moral requirements to safeguard the environment, ensure future sustainability, and back global initiatives to combat food security and climate change. Using embedded technology in smart tobacco cultivation with organic fertilizers and arbuscular mycorrhizal fungus (AMF) raises ethical concerns even with the financial benefits. These techniques lower chemical exposure and advance equity, but they also run the danger of endangering the fertility and health of the soil, so endangering long-term viability. Sustainability, accountability, and openness are among the ethical requirements needed to solve these problems and preserve environmental stewardship in agriculture.

## 6.4 Sustainability Plan

A sustainability plan, by defining goals, involving stakeholders, and reducing environmental impact, promotes long-term profitability and environmental stewardship. It stresses economic sustainability by putting into practice affordable growth-promoting strategies. Social responsibility is promoted by participation in the society and fair employment standards. Metrics guarantee continuous improvement and track advancement; important elements are monitoring and assessment. Incorporating arbuscular mycorrhizal fungus to enhance soil health, employing organic fertilizers, teaching farmers, and deploying Internet of Things sensors for resource management are all part of this plan for smart tobacco cultivation. By balancing financial benefits with social and environmental obligations, this all-surrounding plan guarantees sustainable practices and community support. A paradigm for agricultural education, stressing the value of combining technology with sustainable practices, can be provided by the effective application and results of this research. All things considered, this study may benefit a lot of facets of society by promoting a more prosperous, equitable, and sustainable agriculture industry.

### 6.5 Summery

Beneficial aspects of research are described in this chapter. By use of organic fertilizers, arbuscular mycorrhizal fungi (AMF), and embedded technology, this study aims to increase the sustainability of tobacco crops. While organic fertilizers improve soil quality and stop pollution, Internet of Things sensors improve farming operations. Both soil structure and nitrogen uptake are improved by AMF. To guarantee socially and economically workable tobacco cultivation, the approach combines biodiversity, efficient water use, economic analysis, farmer education, and community involvement.

# Chapter 7

# Conclusion and Future Work

## 7.1 Conclusions

In this study, we are able to uptake phosphorus level on soil though the Arbuscular Mycorrhizal Fungi (AMF) inoculation. As phosphorus is essential for plant and root level. So, based on phosphorus (p) value from the NPK dataset we classify NPK value to predict the soil quality. By employing classification algorithm as follows Random Forest, Decision Tree, SVM, Naïve Bayes and Gradient Boosting we achieved highest accuracy from Gradient Boosting algorithm. Our approach helps us to implement smart agriculture for tobacco cultivation. In Tobacco cultivation, soil quality can be check by farmers though using our methodology. At the end of the day, most advantageous part is leveraging all of our work we can easily reduce the use of chemical fertilizers by replacing it with AMF inoculation and applying organic fertilizers. This will be very sustainable for environment and also make financial, economic benefit.

## 7.2 Further Suggested Works

We have limited parameter for predicting soil quality. There are also some other features like soil temperature, Soil moisture, Soil Zinc or Ion level, and weather data which can be use to predict soil quality. Moreover, In Future using more parameter and build system for real time data monitoring will be more helpful for the farmers.

## 7.3 Limitations/ Conflict of Interest

We have some limitation so that we can't implement our proposed approach for better. To add more parameter, we need more sensor. This sensor can be more expensive and complex to maintain. It will make our proposed system more expensive. Robust infrastructure can be need to develop real time data monitoring. Ensuring power supply, train the farmers is more difficult in rural area. Also, proving technical support is so difficult.

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## APPENDIX A

### *Include the Mapping of COURSE OUTCOMES, COMPLEX ENGINEERING PROBLEMS (EP) AND COMPLEX ENGINEERING ACTIVITIES (EA) ADDRESSING*

**Title:**

**Harnessing Embedded Technology For Smart Tobacco Agriculture With Arbuscular Mycorrhizal Fungai and Organic Fertilizers.**

**Student ID: [201-15-3142 & 201-15-13678]**

| CO | CO Descriptions | PO |
|---|---|---|
| | **Phase -I** | |
| **CO1** | Integrate recently gained and previously acquired knowledge to classify a Soil quality for the Final Year Design Project (FYDP) | **PO1** |
| **CO2** | Analyze different aspects of the goals in designing a solution for this FYDP | **PO2** |
| **CO3** | Explore diverse problem domains through a literature review, delineate the issues, and establish this goals for the FYDP | **PO4** |
| **CO4** | Perform economic evaluation and cost estimation and employ suitable project management procedures throughout the development life cycle of the FYDP | **PO11** |
| | **Phase -II** | |
| **CO5** | Design and develop technical solutions and system components or processes that meet specified requirements, ensuring compliance with public health and safety standards, as well as considering cultural, socioeconomic, and environmental factors in this FYDP | **PO3** |
| **CO6** | Choose and apply appropriate methodologies, resources, and contemporary engineering and IoT technologies to address complex engineering processes, encompassing prediction and modeling, while adhering to relevant constraints in this FYDP | **PO5** |

| | | |
|---|---|---|
| **CO7** | Analyze societal, health, safety, legal, and cultural considerations, along with associated responsibilities, in the context of professional engineering practice and the resolution of this problem, employing logical reasoning guided by contextual understanding. | **PO6** |
| **CO8** | Comprehend and evaluate the enduring sustainability and impact of professional engineering endeavors in addressing intricate engineering challenges within social and environmental frameworks. | **PO7** |
| **CO9** | Implement ethical principles and adhere to professional standards and norms in this FYDP | **PO8** |
| **CO10** | Capable of operating proficiently both individually and as a team member or leader across diverse teams and interdisciplinary settings in this FYDP. | **PO9** |
| **CO11** | Proficiently communicate with the engineering community and broader society regarding complex engineering endeavors, including the ability to comprehend and generate comprehensive reports and design documentation, as well as provide and receive clear instructions throughout this FYDP. | **PO10** |
| **CO12** | Acknowledge the importance of self-directed and life-long learning within the evolving landscape of technology, and possess the readiness and capability to engage in lifelong learning endeavors. | **PO12** |

## Addressing CO (1 to 8), Knowledge Profile (K), Attainment of Complex Engineering Problems (EP), and Attainment of Complex Engineering Activities (EA)

**Addressing CO (1 to 8), Knowledge Profile (K), Attainment of Complex Engineering Problems (EP):**

| SN | EP Definition | Attainment | CO | Justification<br><br>(with Knowledge Profile) | References |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| **1.** | **EP1: Depth of Knowledge required** | Yes | CO1, CO2, CO3, CO5, CO6, CO7 and CO8 | This project demonstrates **fundamental engineering (K3) and specialist Knowledge (k4)** principles by employing classification machine learning models to predict the soil quality. Five classification model has been used to predict binary classification. | **Page no:** [17] **Section:** [4.2] **Page no:** [19] **Section:** [4.3] |
| | | | | The project applies **engineering practice & design (K5)** by the figure of process of experiments. The project addresses **engineering practice & technology (K6)** by employing model. | **Page no:** [20] **Section:** [5.2] **Page no:** [17-18] **Section:** [4.2] |
| | | | | This project ensures to **K8(Research Literature)** by synthesizing insights from recent studies, to showcasing a comprehensive understanding of current methodologies. | **Page no:** [5-6] **Section:** [2.2, 2.3] |

| | | | | | |
|---|---|---|---|---|---|
| **2.** | **EP2: Range of Conflicting Requirements** | Yes | CO2, and CO7 | This project addresses **EP-2** by recognizing the soil quality prediction, including limitations of traditional methods and the complexities of integrating model. Through comparative analysis, it confronts challenges in understanding spatial distributions, offering insights for refining diagnostic methodologies. | **Page no:** [7,26] **Section:** [2.4, 7.3] |
| **3.** | **EP3: Depth of analysis required** | Yes | CO2, and CO6 | This project addresses **EP-3** by meticulously comparing experimental outcomes, highlighting machine Learning as the chosen significant solution for multiple potential approaches. | **Page no:** [16-18] **Section:** [4.2] |
| **4.** | **EP4: Familiarity of Issues** | Yes | CO8 | This project's interdisciplinary approach extends beyond computer science and engineering, impacting smart agriculture which indicates **EP-4**. | **Page no:** [8-12] **Section:** [3.2] |

| | | | | | |
|---|---|---|---|---|---|
| **5.** | **EP5: Extends of application codes** | No | CO5 | N/A | N/A |
| **6.** | **EP6: Extends of stakeholders involved and conflicting** | No | CO8 | N/A | N/A |
| **7.** | **EP7: Interdependence** | Yes | CO5 | This project's comprehensive approach addresses high-level problems by integrating various components across data collection, statistical analysis, and proposed methodology, ensuring a holistic solution to complex challenges in **EP-7**. | **Page no:** [8-15] **Section:** [3.2, 3.3, 3.4] |

**Addressing CO11 with Complex Engineering Activities (EA) [Some or all of the following]:**

| SN | EA Definition | Attainment | CO | Justification | References |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| **1.** | **EA1: Range of resources** | Yes | CO11 | Our project utilizes diverse resources such as high-performance computing infrastructure, annotated datasets, and ethical considerations to ensure systematic research and contribute to advancements in pneumonia detection through transfer learning and deep CNNs. | **Page no:** [12-15,24] **Section:** [3.3 ,6.3] |
| **2.** | **EA2: Level of interaction** | No | | N/A | N/A |
| **3.** | **EA3: Innovation** | No | | N/A | N/A |

| | | | | | |
|---|---|---|---|---|---|
| **4.** | **EA4: Consequences for society and the environment** | Yes | | This project contributes to society by improving smart agriculture through ML methods, while also promoting environmental sustainability by employing efficient computational resources and adhering to ethical guidelines for smart tobacco cultivation. | **Page no:** [24-25] **Section:** [ 6.2, 6.3] |
| **5.** | **EA-5: Familiarity** | Yes | | This project expands upon existing research by examining a novel approach and a comprehensive comparative analysis, offering new insights into the field. | **Page no:** [8-9] **Section:** [3.2] |

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