Department of Electrical & Electronics Engineering

MINOR PROJECT REPORT
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Title: Prototype of Greenhouse Automation - Controlling Temperature, Humidity and Soil Moisture for Optimal Plant Growth Along with Crop Prediction

B.E. 7th Semester (Branch: EEE)

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a) Introduction:

Introducing greenhouse automation systems can revolutionize agriculture by enabling precise cultivation in controlled environments. Greenhouses, designed to facilitate plant growth under controlled climatic conditions, play a pivotal role in the agriculture and horticulture sectors.

Farmers often lack accurate information about weather conditions, leading to imprecise agricultural practices based on intuition and observation. This variability can be addressed through greenhouse automation. By implementing this project, we can significantly enhance productivity. The system focuses on monitoring and controlling key parameters crucial for greenhouse operations, such as soil moisture, humidity, and temperature. These parameters are regulated artificially within the greenhouse to create an optimal growth environment for plants. The automated system is designed to efficiently manage various parameters, including temperature and humidity. This smart agricultural technique ensures that critical factors are maintained within the desired range. Consequently, it reduces the need for manual oversight, minimizing errors that can occur during manual operations.

Precision agriculture, driven by technology and data analytics, is transforming traditional farming practices. Soil nutrients (nitrogen, phosphorous, potassium) and environmental factors (temperature, pH, humidity, rainfall) are critical to crop growth. Integrating these elements in a comprehensive recommendation system enables precise decision-making for resource optimization and enhanced crop performance. By understanding the intricate relationships between soil health, climate, and crop productivity, this project aims to empower farmers with tailored strategies to achieve sustainable and resilient food production amidst evolving challenges.

b) Literature Survey:

Numerous studies have emphasized the need for automation in greenhouse agriculture. Vanthoor et al. (2017) [1] highlighted the potential benefits of automation, including precise control of temperature, humidity, and lighting, resulting in improved crop quality and reduced energy consumption. Automation also allows for remote monitoring and control, enabling farmers to make data-driven decisions in real-time (Bakker et al., 2011) [2].

This literature survey explores the evolution of greenhouse automation systems, blending insights from pioneering studies with recent advances. Seminal works by Li et al. (2010) [3] and Jones and Smith (2005) [4] underscore the pivotal role of sensor technologies in real-time monitoring for informed decision-making. Wang and Zhang (2008) [5] and Garcia et al. (2012) [6] laid the foundation for advanced control mechanisms, employing algorithms and machine learning for optimal greenhouse conditions.

Recent research by Anderson et al. (2021) [7] and Patel and Gupta (2022) [8] delves into smart energy management, integrating renewable sources for sustainability. Examining the impact on crop productivity, earlier studies by Black et al. (1998) [9] and Liang et al. (2002) [10] emphasize increased yields through precise environmental control. Recent contributions by Chen et al. (2020) [11] and Kim and Lee (2021) [12] demonstrate advancements in improving crop quality under controlled greenhouse conditions. In terms of resource optimization and sustainability, the pioneering work of Brown and Davis (2003) [13] and Robinson et al. (2006) [14] highlights the integration of soil nutrient monitoring and environmental data analytics.

In conclusion, the literature on greenhouse automation and precise agriculture underscores the potential for significant improvements in crop yield, resource utilization, and environmental control. The integration of sensors, actuators, and remote monitoring capabilities has the potential to revolutionize greenhouse agriculture, making it more efficient, sustainable, and economically viable.

c) Research Gap:

The current research in PLC-based greenhouse automation focuses on optimizing temperature, humidity, and soil moisture for plant growth. However, a research gap exists in addressing the dynamic nature of soil composition due to fertilizer additions. Additionally, the integration of a crop recommendation system is hindered by the lack of consideration for real-time soil data and environmental conditions. Closing this gap requires incorporating machine learning models to dynamically recommend crops based on evolving soil composition and environmental parameters. This research direction is crucial for developing an adaptive greenhouse automation system that not only regulates the environment but also provides intelligent recommendations for optimal crop cultivation.

d) Objectives:

1) To design a PLC program simulation to control temperature, humidity and soil moisture for greenhouse management through Do More Designer.
2) To design and simulate a software prototype of the greenhouse system to control the environmental conditions on Proteus ISIS.
3) To set up the hardware for automating the greenhouse.
4) To generate a machine learning model which recommends the crop suitable for particular nature of soil and environmental conditions.

e) Block Diagram:

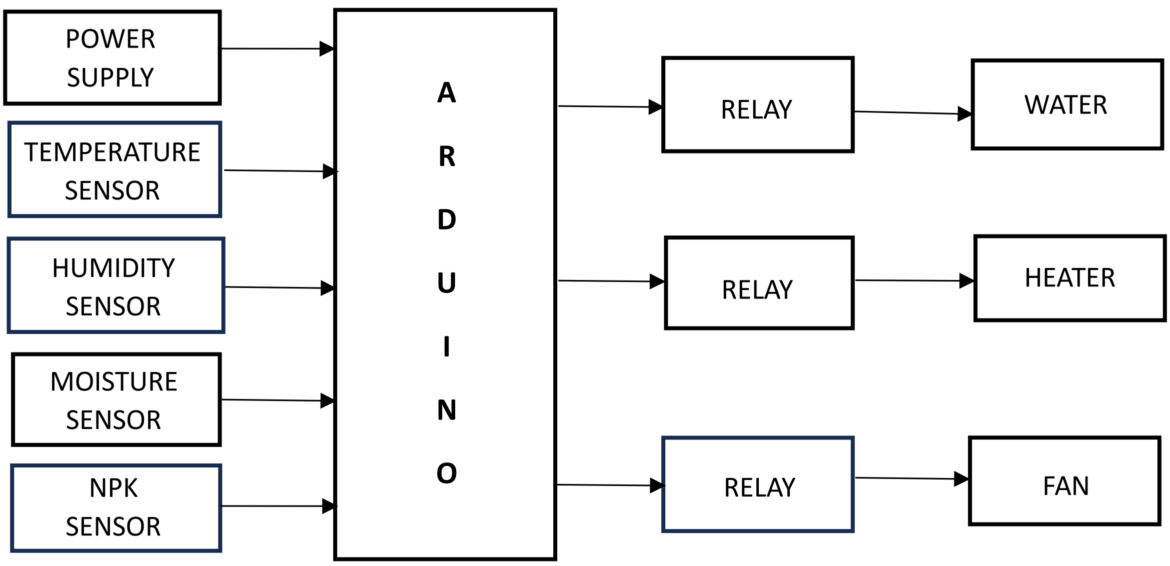

Fig 1: Block diagram representing the greenhouse automation and data collection

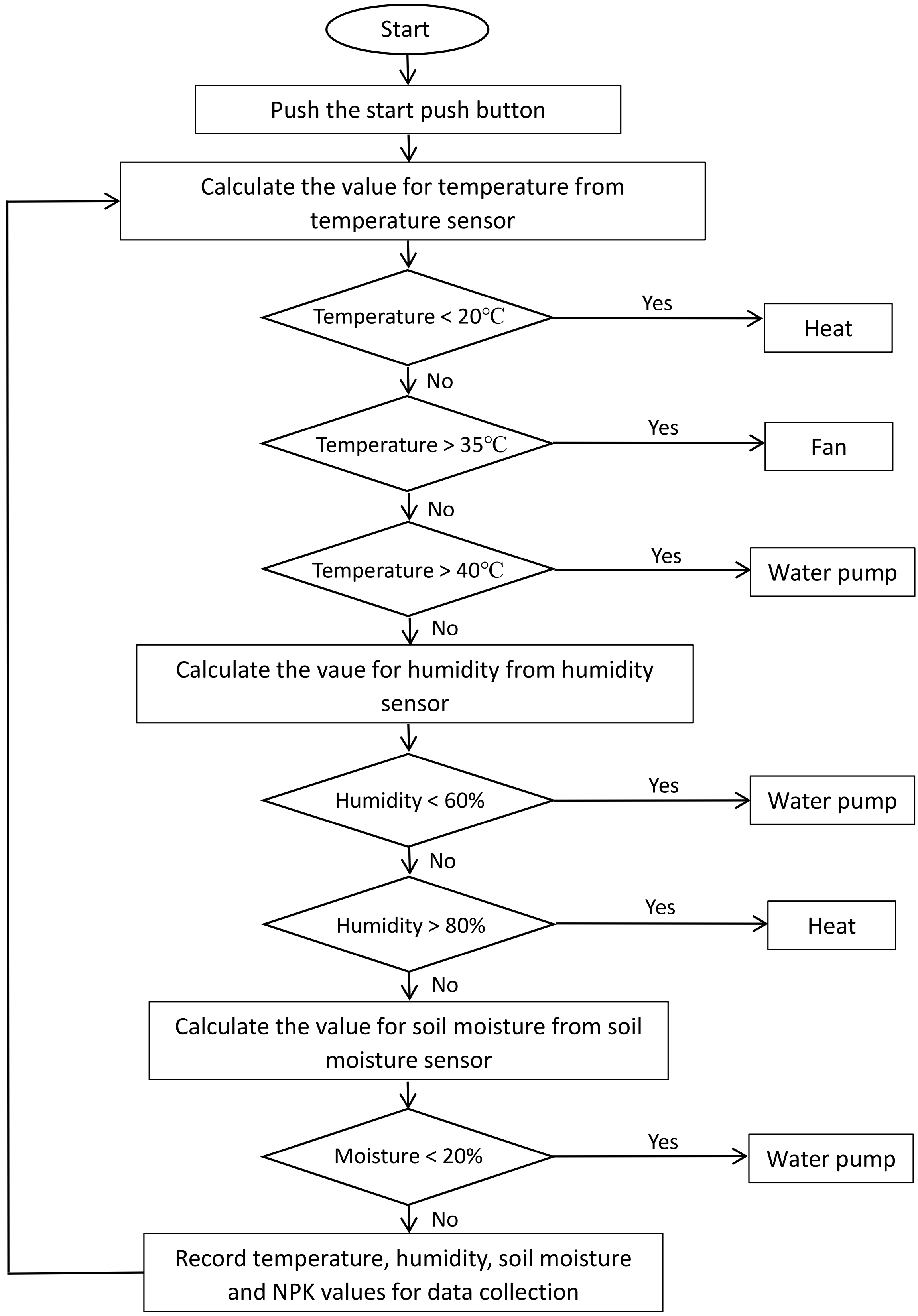

Fig 2: Block diagram representing the pseudo code followed for greenhouse automation

Sensors within the greenhouse continually monitor critical environmental parameters, such as temperature, humidity, soil moisture and values of nitrogen, phosphorous and potassium levels of the soil. The data collected by these sensors is transmitted to Arduino Uno, where it is stored in a database and made available for real-time monitoring and control.

The program serves as an automated control system, ensuring that the environmental conditions in the greenhouse remain within the specified ranges for optimal rice cultivation. The logic is based on sensor inputs measuring temperature, humidity, and soil moisture, and the PLC responds accordingly by activating or deactivating the specified devices (heater, ventilation fan, water pump) to maintain the desired conditions for the crop. If all conditions are within the optimal range (temperature between 20°C and 35°C, humidity between 60% and 80%, and soil moisture between 20% and 25%), no additional actions are taken.

e) Components/Software Used:

1) Do More Designer Software: For PLC programming and simulation.
2) Proteus ISIS: For software prototyping.
3) Sensors: Temperature sensors, humidity sensors, etc for data acquisition.
4) Actuators: Automated irrigation system, ventilation fans, and heaters for control.
5) Central Control Unit: Arduino uno to interface with sensors and actuators.
6) Communication Interface: To implement communication protocols for data exchange between components.
7) Polypropylene Plastic: For covering of the Greenhouse.
8) Jupyter Notebook: For implementing the machine learning model using Python.

f) Work Done:

1) PLC program to control temperature, humidity and soil moisture for greenhouse management.

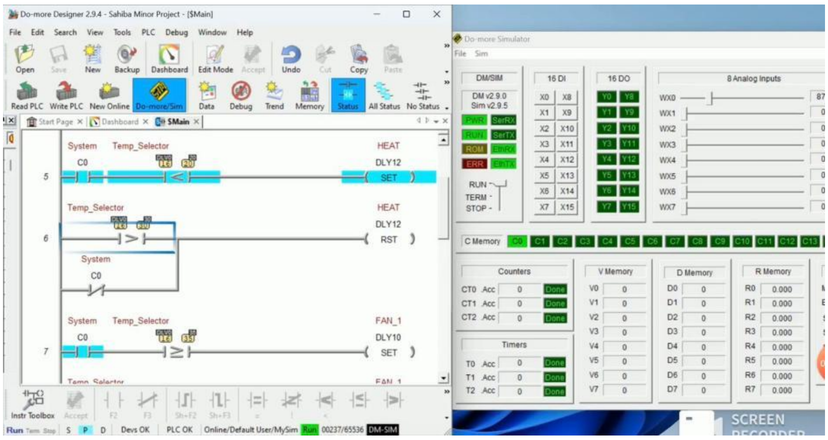

Fig f.1.1: Heater gets turned on when temperature drops below 20° C

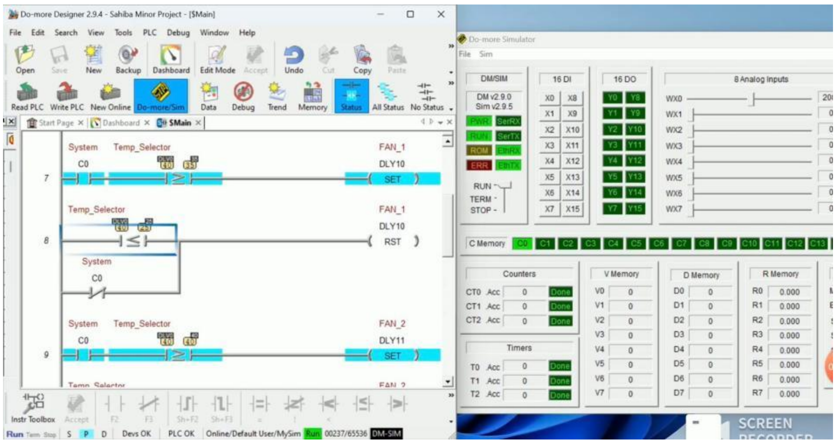

Fig f.1.2: Fan_1 and Fan_2 gets turned on when temperature rises to 40° C

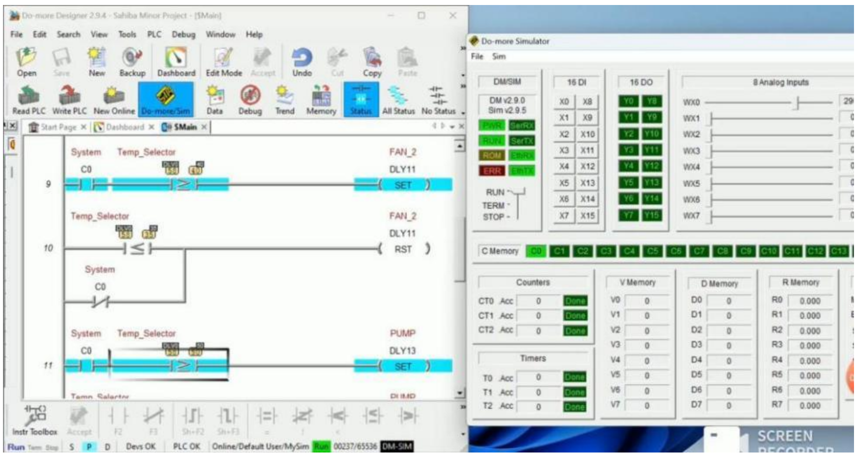

Fig f.1.3: Fan_1, Fan_2 and Pump turns on when temperature rises above 50° C

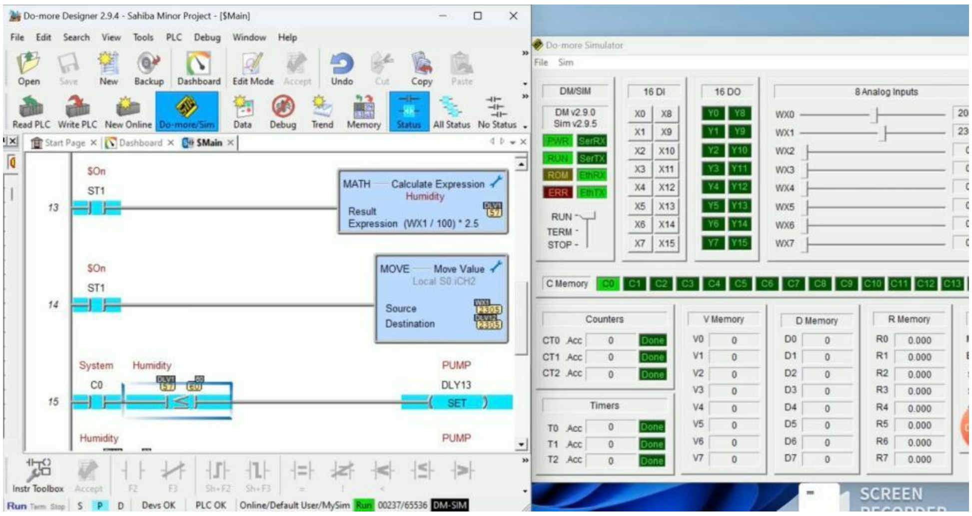

Fig f.1.4: Pump is operated when humidity drops below 60%

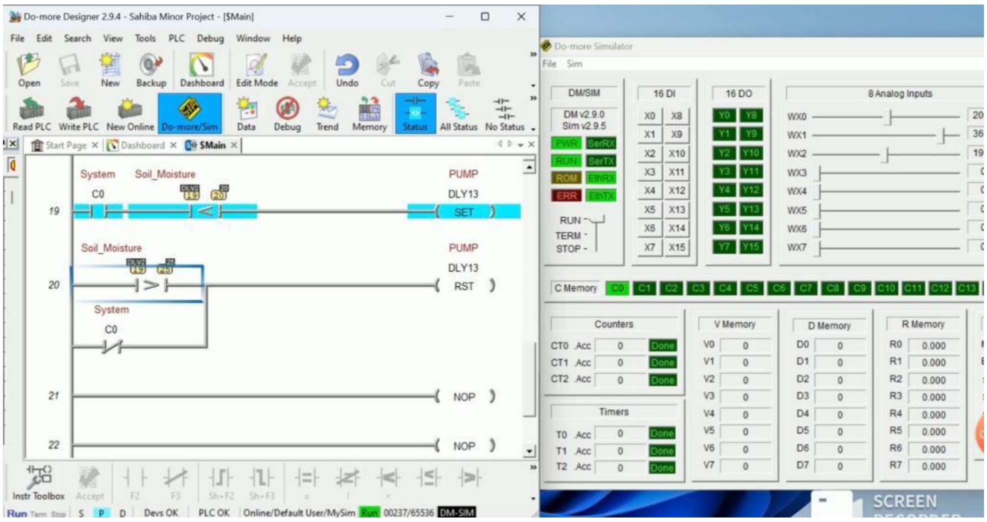

Fig f.1.5: Pump is operated when soil moisture drops below 20%

2) Design and simulate a software prototype of the greenhouse system to control the environmental conditions.

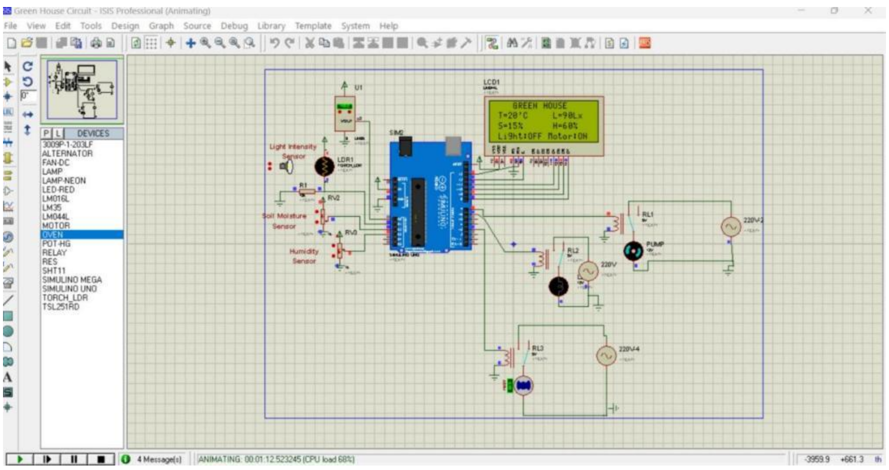

Fig f.2.1: Pump turns on when soil moisture falls below 20%

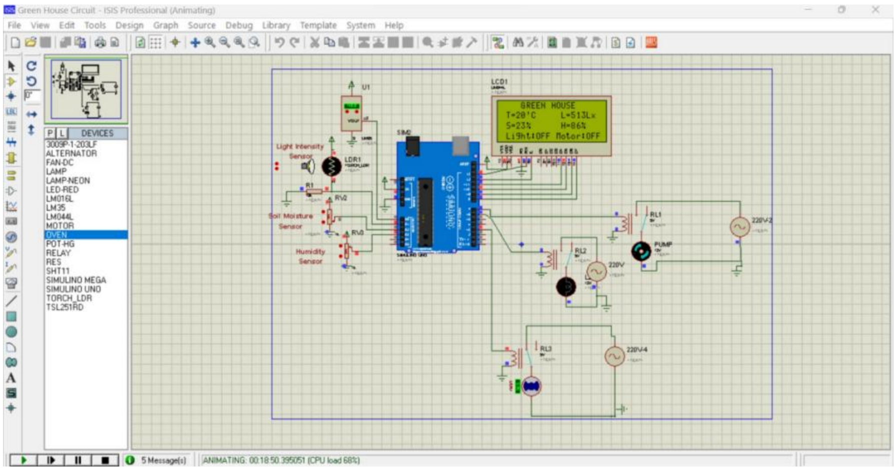

Fig f.2.2: Heater turns on when humidity rises above 80%

3) Hardware setup for automating the greenhouse.

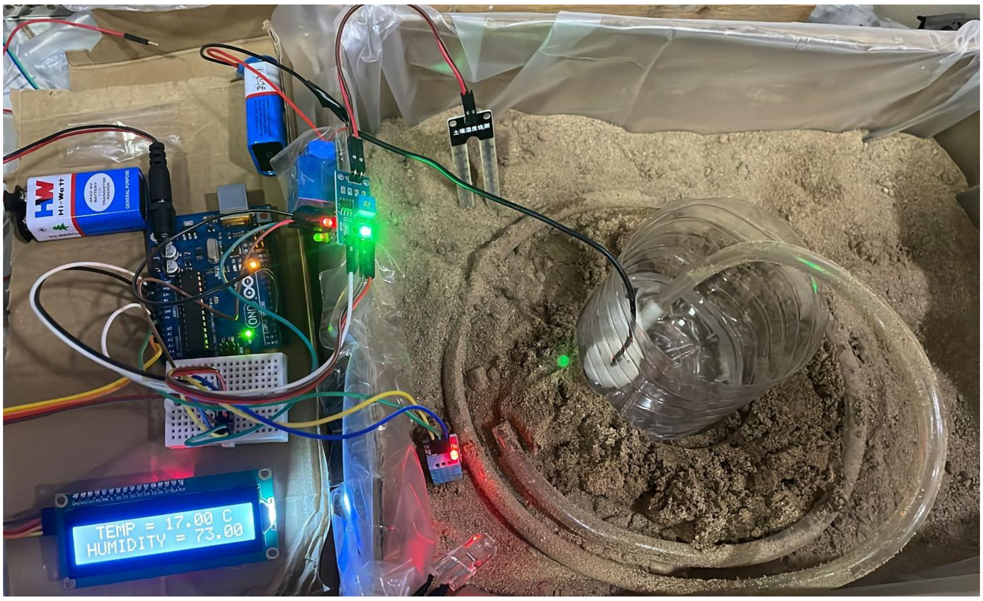

Fig f.3: Hardware setup for greenhouse automation

The Arduino-controlled greenhouse automation system employs a compact hardware setup, featuring an Arduino board as the central processing unit. This board interfaces with a temperature and humidity sensor, specifically a DHT11 or DHT22, to continuously measure the greenhouse conditions. The system utilizes relays to control high-power devices such as a motor pump for watering, a halogen bulb for heating, and a ventilation fan for cooling. The Arduino reads sensor data, compares it with preset thresholds, and activates or deactivates the devices accordingly. For instance, if the temperature falls below the desired range, the halogen bulb is activated for heating, while the ventilation fan kicks in if the temperature exceeds the upper limit. The water pump is employed based on soil moisture levels. This closed-loop system ensures that the greenhouse maintains optimal conditions for crop growth, with the Arduino serving as the brains behind the intelligent decision-making process.

4) Machine Learning model for crop recommendation.

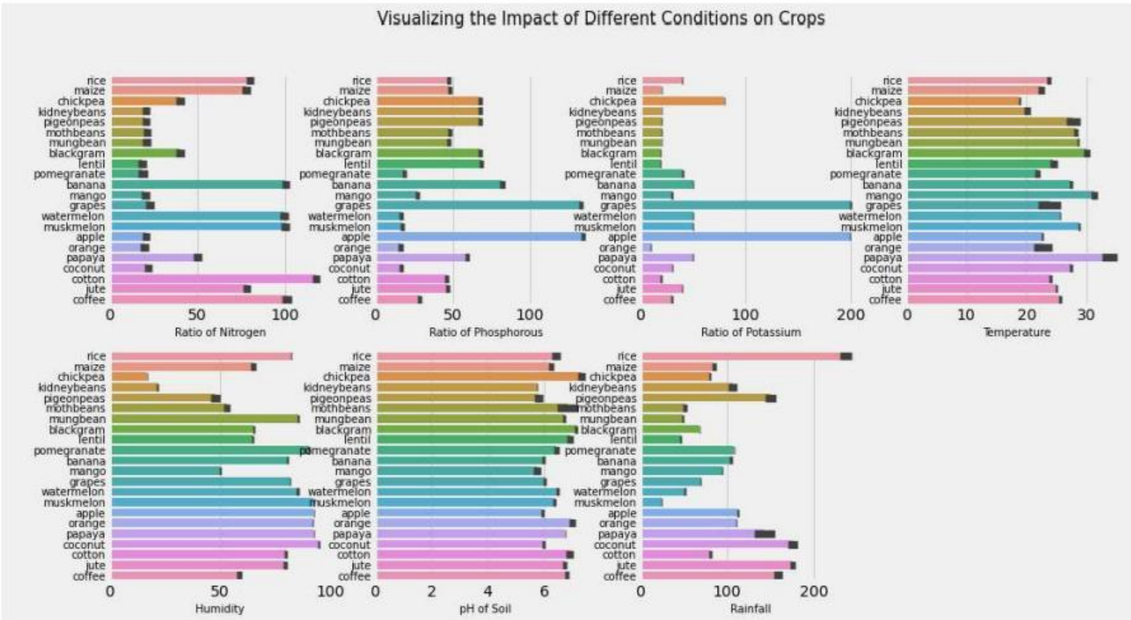

Fig f.4.1: Visualising the impact of different conditions on crops

Utilizing the Python programming language, a comprehensive analysis of agricultural conditions has been conducted and visually represented through a bar graph. This graph illustrates the distribution of diverse crops, taking into account critical soil parameters such as nitrogen, phosphorus, and potassium levels. Additionally, the visualization incorporates essential soil characteristics like pH values, as well as environmental factors such as temperature, humidity, and rainfall. The use of Python for this visualization not only allows for a dynamic and interactive representation of the data but also facilitates a deeper understanding of the intricate relationships between these agricultural variable.

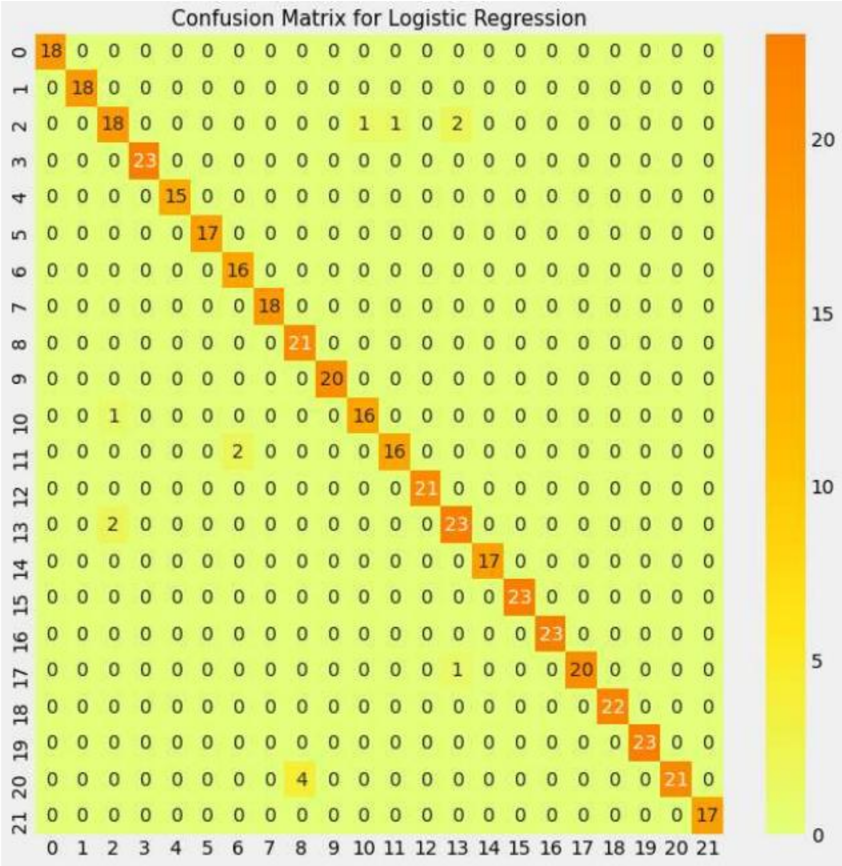

Fig f.4.2: Confusion matrix showing the accuracy of the Machine Learning model

Our logistic regression model, boasting a robust accuracy of 97%, serves as a reliable tool for recommending the most suitable crops based on soil nutrient composition and environmental conditions in a given region. This high accuracy reflects the model's proficiency in making precise predictions. Deploying this model empowers farmers and decision-makers to make informed choices, optimizing crop selection for enhanced agricultural productivity and sustainable land management.

h) References:

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