IntelliGROW

Smart Irrigation and Fertilization System

Capstone Project Progress Report for Mentor Evaluation-1

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1. Project Overview

1.1 Product Perspective

Intelligrow is an innovative product designed to optimize water usage and enhance crop productivity in agricultural and horticultural settings. It combines advanced sensor technology, automation, and data analytics to create an intelligent and efficient irrigation and fertilization solution. Here are some key perspectives to consider from a product standpoint:

- **1. Water Conservation:** One of the primary goals of the smart irrigation and fertigation system is to minimize water wastage. By utilizing real-time weather data and soil moisture sensors, the system can accurately determine the irrigation needs of the crops. It ensures that water is delivered precisely when and where it is needed.

- **2. Precision Fertigation:** In addition to irrigation, the system incorporates fertigation capabilities. It enables precise and controlled application of fertilizers directly through the irrigation system. By analysing soil conditions and plant nutrient requirements, the system can deliver the right amount of fertilizers at the right time. This precision fertigation approach optimizes nutrient uptake by the crops, leading to improved growth and higher yields.

- **3. Automation and Remote Monitoring:** The system operates autonomously, relieving farmers from manual intervention. Farmers can also monitor and control the system remotely through a web-based dashboard, providing convenience and flexibility.

- **4. Sensor Technology and Data Analytics:** The system employs various sensors such as soil moisture sensors, and soil nutrient sensors to gather real-time data about environmental conditions and crop health. This data is analysed using advanced algorithms to generate insights and recommendations. By harnessing this information, farmers can make data-driven decisions regarding irrigation timing, fertilization requirements, and overall crop management.

By considering these perspectives, the system can offer significant benefits to farmers, including improved crop yields, reduced water and fertilizer consumption, streamlined operations, and increased sustainability in agriculture.

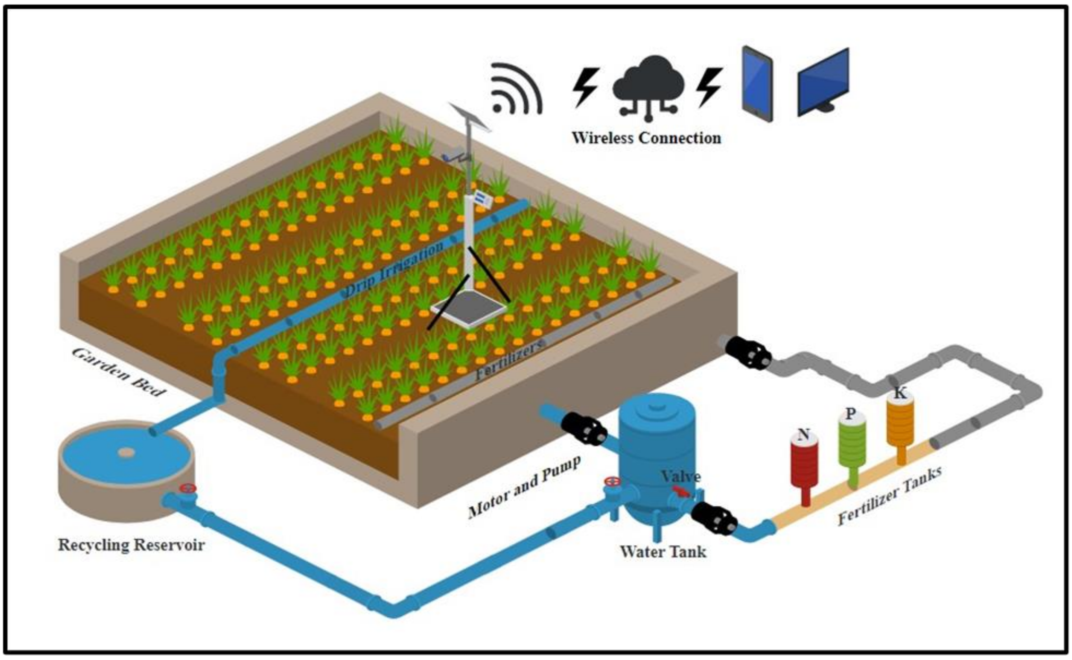

Fig 1.1: The Proposed Irrigation and Fertilization System

1.2 Block Diagram

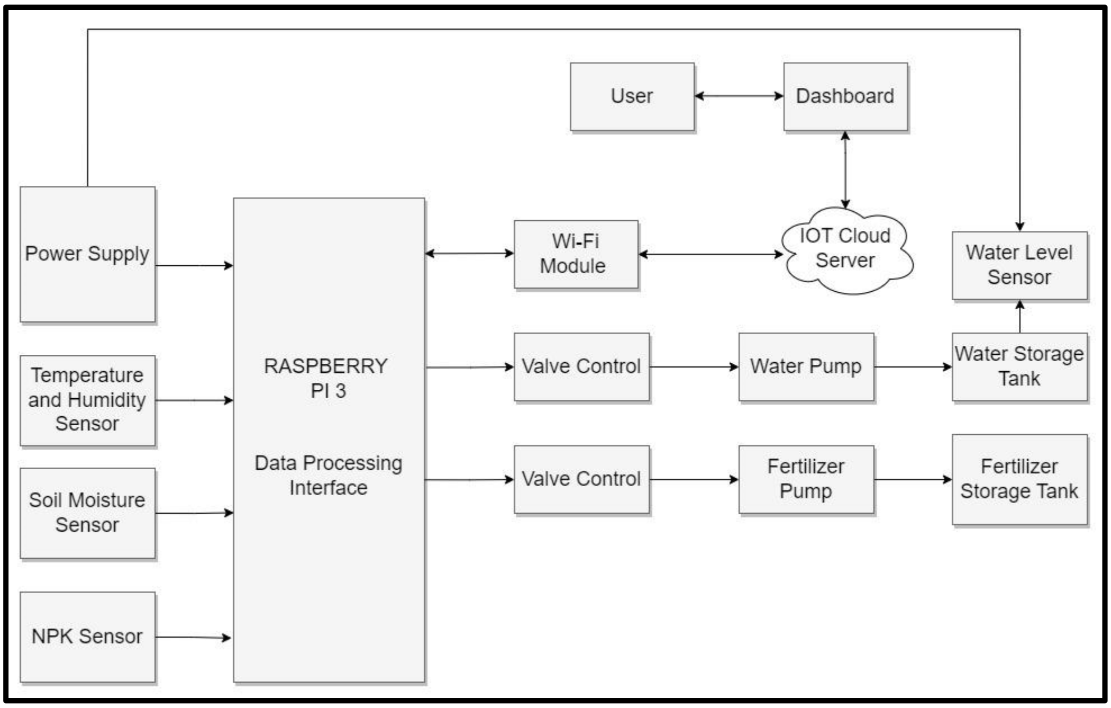

Fig 1.2: Block Diagram for IntelliGROW

Fig. 1.2 provides a block overview of the system and its components. It provides insight into the various sensors and actuators used in the system to accurately measure soil data and plant environmental conditions and their connections with other system modules

2. UML Diagrams

2.1.1 Use-Case Diagram

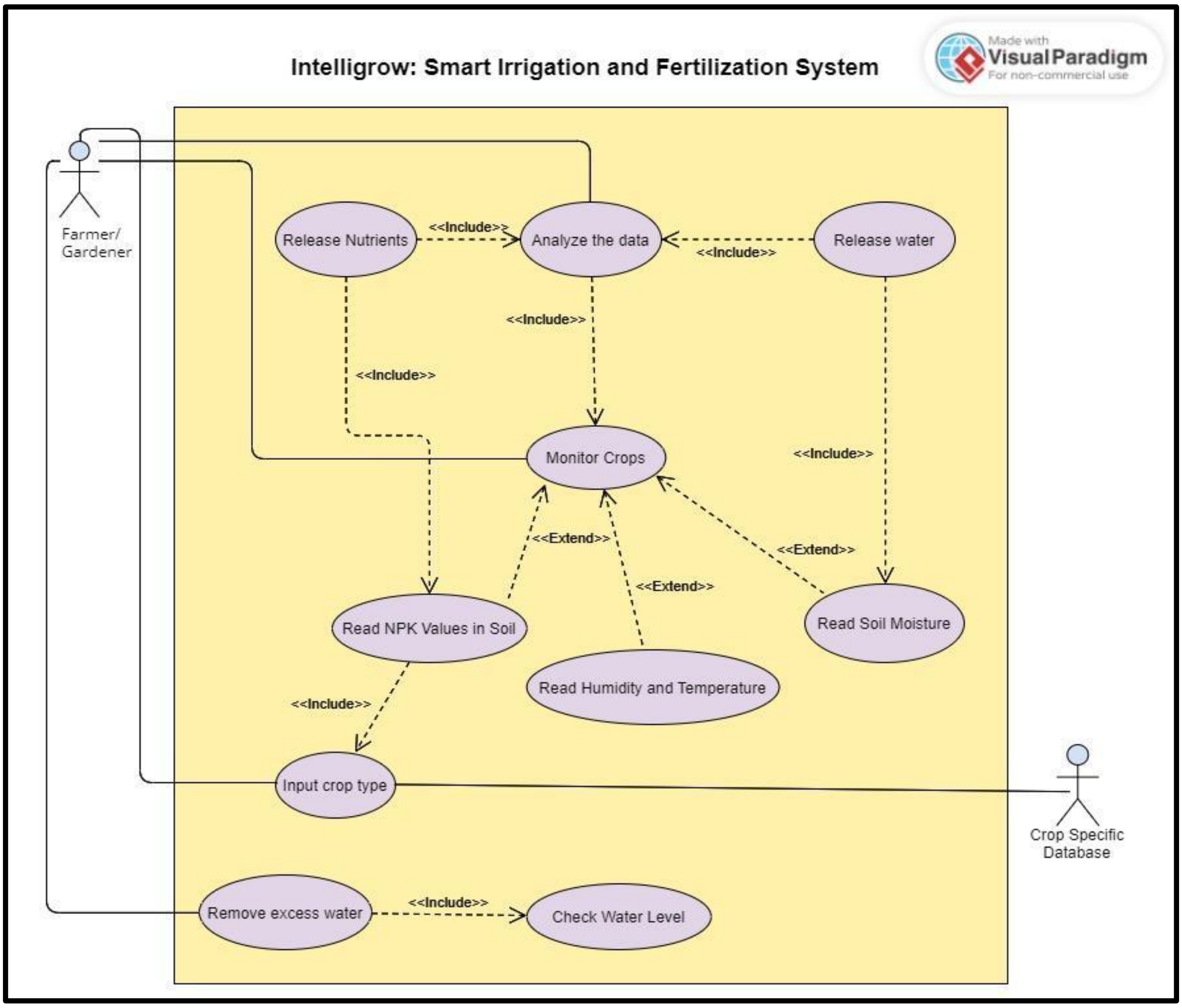

Fig 2.1.: Use Case Diagram for IntelliGROW

The above diagram, labelled as Fig. 2.1, presents the use case diagram for IntelliGrow. Since most of the system is automated, the end user (here, a farmer or gardener) can use the system to monitor crops (which includes reading soil moisture content, NPK levels, temperature, and humidity), analyse and visualize the collected data using a web-dashboard and actuate the appropriate decisions as per the controller unit of the system The details about crop and its types are fed into the system by the user, which further gets stored into the Crop Specific Database of the system.

2.1.2 Use-Case Template

1.Use Case Title	Input Crop Type
2.Abbreviated Title	Input Crop Type
3. Use Case Id	1
4. Actors	Farmers, Gardeners
5. Description With this facility, the user will input/register the desired crop in the system and get the nutrition requirement for it.	
5.1 Pre-Conditions The user must know about the type of crop being grown.	
5.2 Task Sequence **Normal Scenario** 1. (AA) The user inputs the desired crop type into the system 2. (SR) The system checks the desired crop in the database and return nutrient requirements for it **Alternate Scenario** 1. If the desired crop is not present in the database, then the system will throw an exception of “Crop not found”	
5.3 Post Conditions The system will start working for the registered crop.	
6. Modification History:	
7. Author: Romil Gupta	

Use Cases 2-4 are part of Monitor Crops and are discussed individually.

1.Use Case Title	Read Soil Moisture
2.Abbreviated Title	Read Soil Moisture
3.Use Case Id	2
4.Actors	Farmers, Gardeners
5.Description With this facility, the user is informed about the soil moisture content via the deployed soil moisture sensors of the system.	
5.1 Pre-Conditions The soil moisture sensor is properly installed and connected to the Control System	
5.2 Task Sequence **Normal Scenario** 1. (SR) The Soil Moisture Sensor measures the soil moisture level at the desired location. 2. (SR) The Soil Moisture Sensor sends the recorded soil moisture data to the Control System. 3. (SR) The Control System receives the soil moisture data and records it in the system.	
5.3 Post Conditions The Control System analyses the soil moisture data to determine the appropriate irrigation needs	
6. Modification History:	
7. Author: Nishant Sharma	

1.Use Case Title	Read Temperature and Humidity
2.Abbreviated Title	Read Temperature and Humidity
3.Use Case Id	3
4.Actors	Farmers, Gardeners
5.Description With this facility, the user is informed about the soil temperature and humidity of the surroundings via the deployed sensors of the system.	
5.1 Pre-Conditions The Temperature and Humidity Sensor is properly installed and connected to the Control System	
5.2 Task Sequence **Normal Scenario** 1. (SR) The Temperature and Humidity Sensor measures the soil temperature and the atmospheric humidity. 2. (SR) The Humidity and temperature Sensor sends the recorded soil temperature and atmospheric humidity data to the Control System. 3. (SR) The Control System receives the temperature and humidity data and records it in the system.	
5.3 Post Conditions The Control System analyses the humidity and temperature data to determine the appropriate irrigation needs	
6. Modification History:	
7. Author: Vardaan Khosla	

1.Use Case Title	Read N, P, K values
2.Abbreviated Title	Read N, P, K values
3.Use Case Id	4
4.Actors	Farmers, Gardeners
5.Description With this facility, the user is informed about the nutrient levels in soil via the deployed NPK sensor of the system.	
5.1 Pre-Conditions The N, P, K Sensor is properly installed and connected to the Control System.	
5.2 Task Sequence **Normal Scenario** 1. (SR) The N, P, K Sensor checks for various salts in soil such as N, P and K at desired locations. 2. (SR) The N, P, K Sensor sends the recorded nutrient level data to the Control System. 3. (SR) The Control System receives the appropriate nutrition data and records it in the system.	
5.3 Post Conditions The Control System analyses the recorded nutrient data (N, P, and K levels) to determine the appropriate fertilization needs.	
6. Modification History:	
7. Author: Satvik Maheshwari	

1.Use Case Title	Analyse sensor data
2.Abbreviated Title	Analyse sensor data
3.Use Case Id	5
4.Actors	Farmers, Gardeners
5.Description With this facility, the user and the system can analyse the data obtained by various sensors and release water and fertilizers in accordance with it.	
5.1 Pre-Conditions 1.The sensors (Soil Moisture Sensor, Nutrient Sensors) have properly measured and recorded the data. 2.The data has been recorded in the system.	
5.2 Task Sequence **Normal Scenario** 1. (SR) The Control System retrieves the recorded sensor data from the system. 2. (SR) The Control System analyses the data to determine the appropriate irrigation and fertilization needs for the crops.	
5.3 Post Conditions 1.The Control System releases the optimum water and fertilizers using drip irrigation in accordance with requirement specified by sensors.	
6. Modification History:	
7. Author: Sundaram Srivastava	

1.Use Case Title	Remove excess water
2.Abbreviated Title	Remove excess water
3.Use Case Id	6
4.Actors	Farmers, Gardeners

5.Description

With this facility, the system will check the water level in soil and remove excess water from it.

5.1 Pre-Conditions

1.The Water Depth Sensor is installed and connected properly.

2.The Water Depth Sensor has detected excess water in the soil I.e., water above the threshold level.

5.2 Task Sequence

Normal Scenario

1. The Water Depth Sensor detects excess water in the soil.

2. The Water Depth Sensor sends a signal to the Water Storage System to activate the suction facility.

3. The Water Storage System uses the suction facility to remove excess water from the soil.

4. The excess water is stored in the water reservoir for future use.

5.3 Post Conditions

1. The Water Storage System successfully removes the excess water from the soil and stores it in the storage tank for future use.

6. Modification History:

7. Author: Romil Gupta

3. Activity Diagram

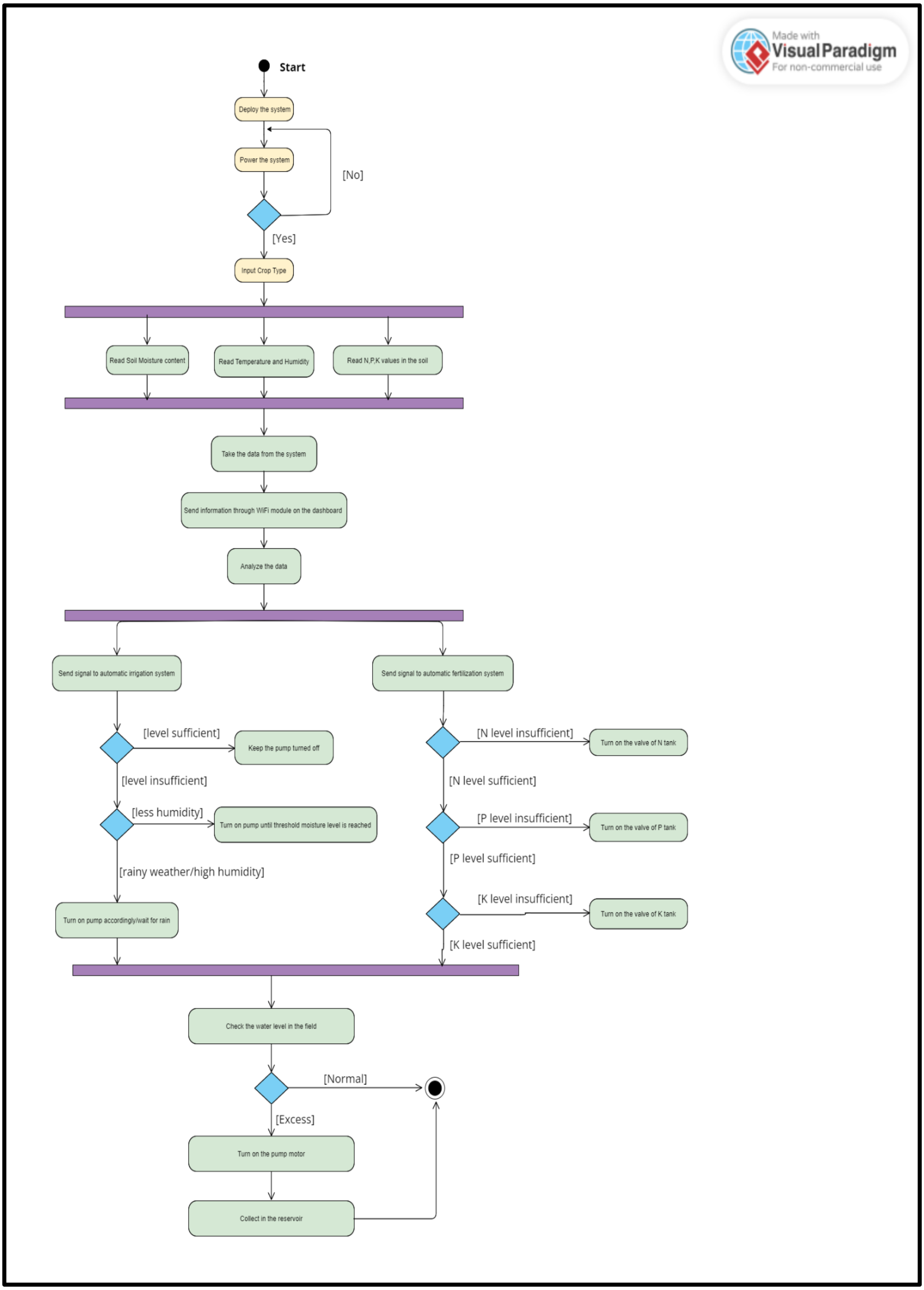

Fig 3: Activity Diagram

Fig. 3 represents an activity diagram that illustrates the behaviour of the smart irrigation and fertilization system. The diagram visually displays the control flow from the start of an activity to its end while highlighting various decision pathways that can be taken during its execution. It also gives an overview of how the system works and how its various components interact.

4. Requirement Analysis

4.1 Functional Requirements

Detailed description of functional requirements:

Table 1: Develop a monitoring system for plant conditions

Purpose	**To monitor soil conditions, plant health, and environmental factors such as temperature and humidity**
Inputs	Readings of soil moisture sensor, temperature and humidity sensor, NPK sensor, microcontroller, water pump, fertilizers.
Processing	Collect real-time data from sensors, analyse data to determine optimal irrigation and fertilization timing, activate water pump and fertilizer dispenser.
Outputs	Real-time sensor data.

Table 2: Automate the system for optimal irrigation and fertilization

Purpose	**To predict the optimal timing for irrigation and fertilization using real-time data analysis**
Inputs	Real-time sensor data, threshold levels.
Processing	Analyse sensor data and compare to threshold values to determine optimal irrigation and fertilization timing, activate water pump and fertilizer dispenser.
Outputs	Activate irrigation and fertilization system.

Table 3: Utilising a suction equipment to prevent waterlogging

Purpose	**To remove excess water (especially during rainy season) from the area and store it in a tank to prevent waterlogging**
Inputs	Suction pump, water storage tank.
Processing	Activate suction pump to remove excess rainwater from the area, store water in the storage tank.
Outputs	Prevention of waterlogging in the crop area.

Table 4: Develop a user interface for the web application

Purpose	**To provide a user-friendly interface for farmers to monitor their crops**
Inputs	Real-time sensor data, irrigation and fertilization schedules.
Processing	Display real-time sensor data in graphical and tabular formats, display irrigation and fertilization schedules in a calendar format.
Outputs	User-friendly web interface for remote monitoring of crop conditions and irrigation and fertilization schedules.

Table 5: Connectivity and data transfer

Purpose	**To ensure seamless connectivity between on-field sensors, microcontrollers, and the web application**
Inputs	Internet connectivity, microcontrollers, sensors.
Processing	Connect sensors and microcontrollers to the internet, transfer data to the web application.
Outputs	Real-time sensor data and irrigation and fertilization schedules on the web application.

4.2 Non-Functional Requirements

- **Availability:** The system should be reliable and able to function 24/7.
- **Scalability:** The system should be scalable and able to handle different types of plants and varying farm sizes.
- **Modifiability:** The system should be easy to install, maintain, and repair.
- **Security:** The system should be secure and protect the farmer's data and privacy.
- **Sustainability:** The system should be energy-efficient and environmentally friendly.
- **Usability:** The user interface of the mobile or web application should be user-friendly and easy to navigate.

5. Design Model

5.1 Class Diagram

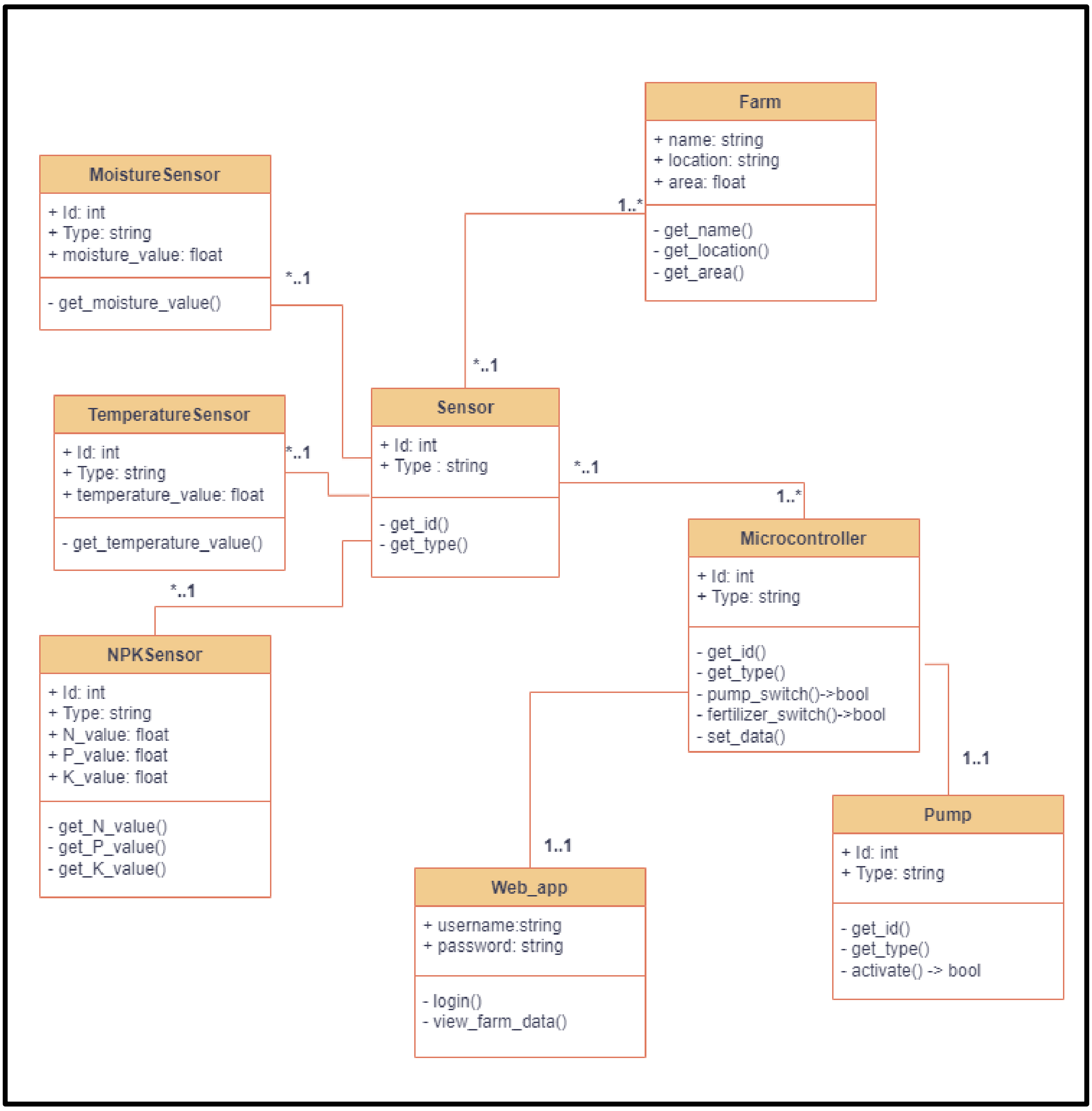

Fig 5.1: Class Diagram for IntelliGROW

Fig. 5.1 depicts the class diagram for IntelliGROW that provides an overview of the different classes in the system and how they are related.

5.2 Data Design - ER Diagram

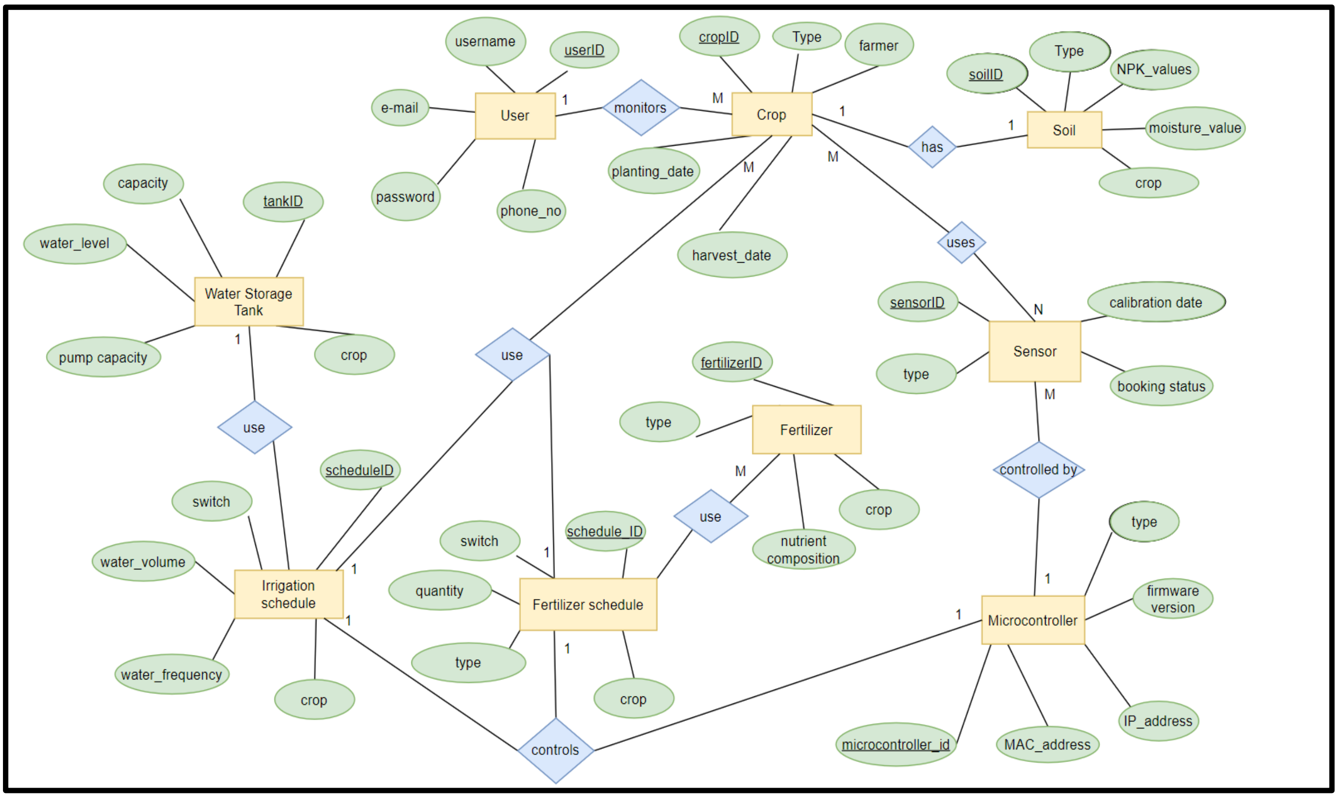

Fig 5.2: Entity-Relationship (ER) Diagram for IntelliGROW

The ER (Entity-Relationship) Diagram in Fig. 5.2 represents the relationships between different entities and their attributes.

5.3 Data Flow Diagrams (DFD)

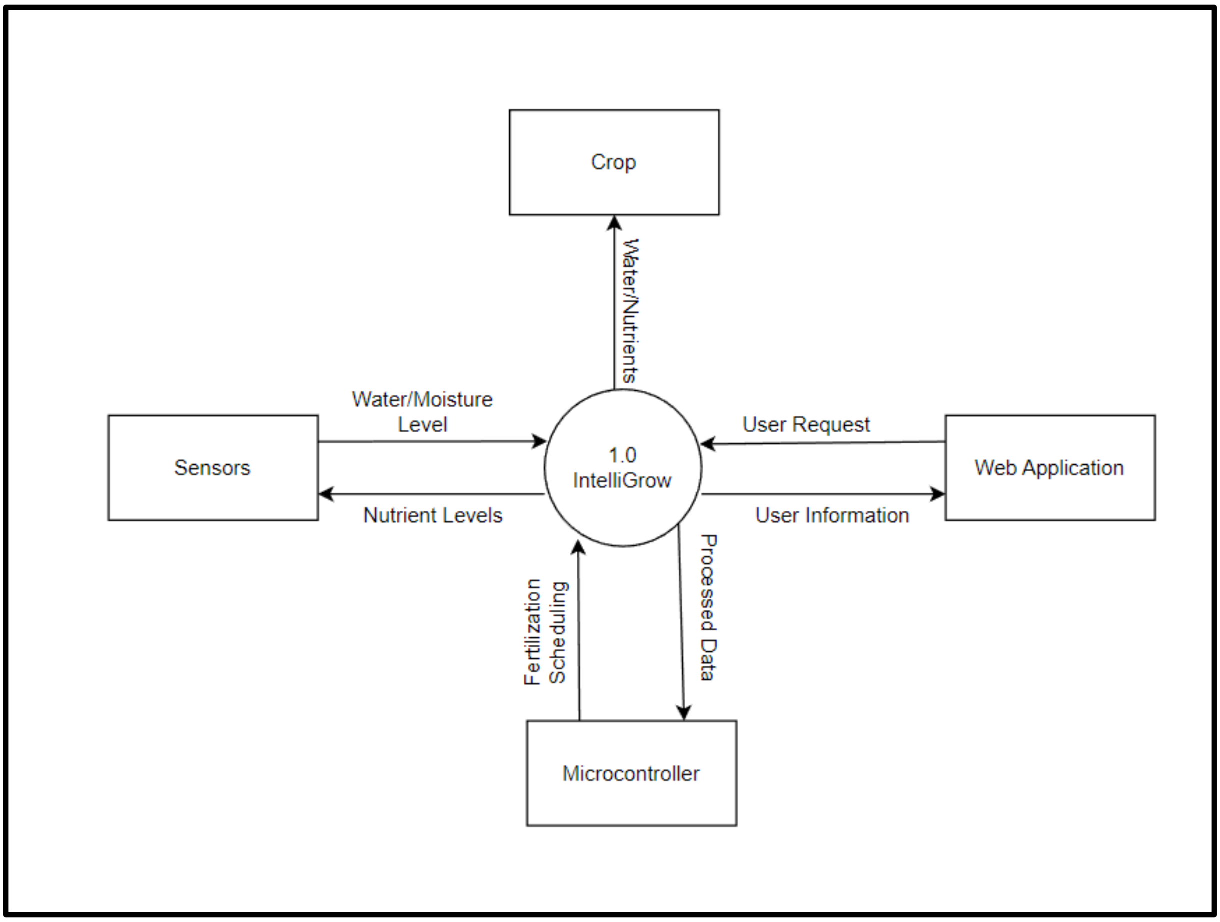

Fig 5.3.1: Level 0 DFD

Fig. 5.3.1 displays a Level 0 Data Flow Diagram (DFD), which presents a high-level view of the complete system, demonstrating key processes and data exchange between various components.

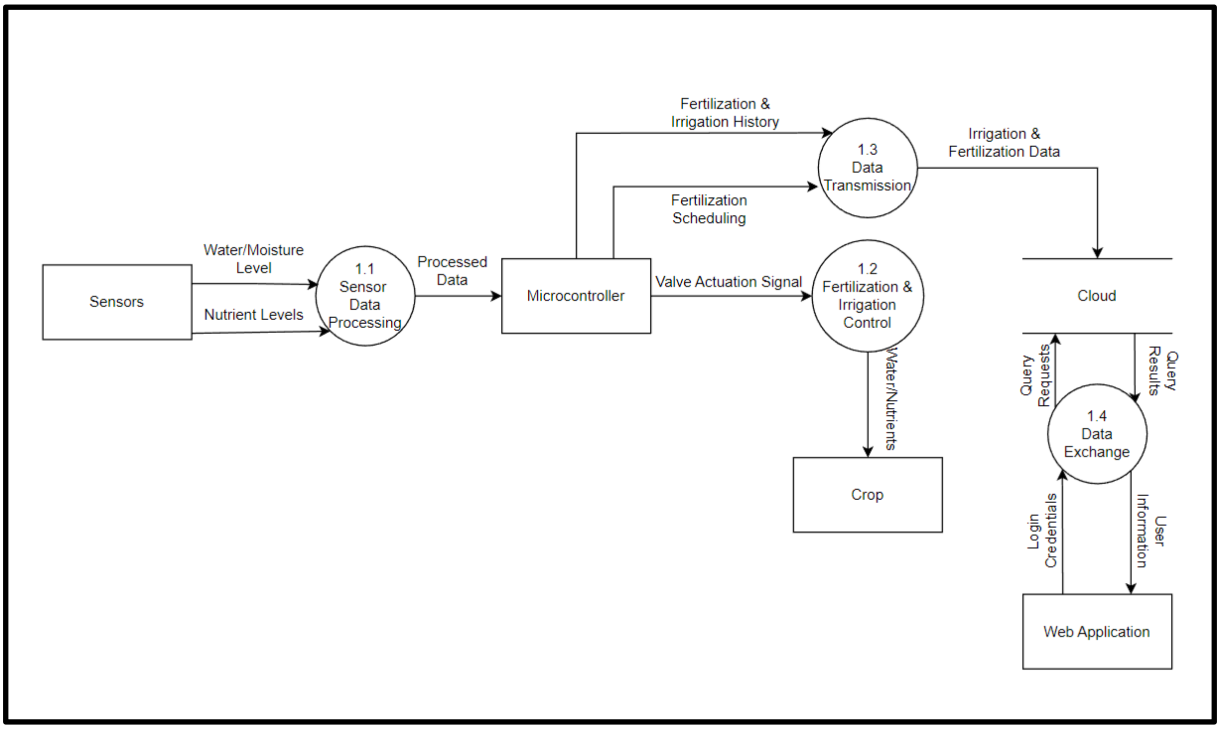

Fig 5.3.2: Level 1 DFD

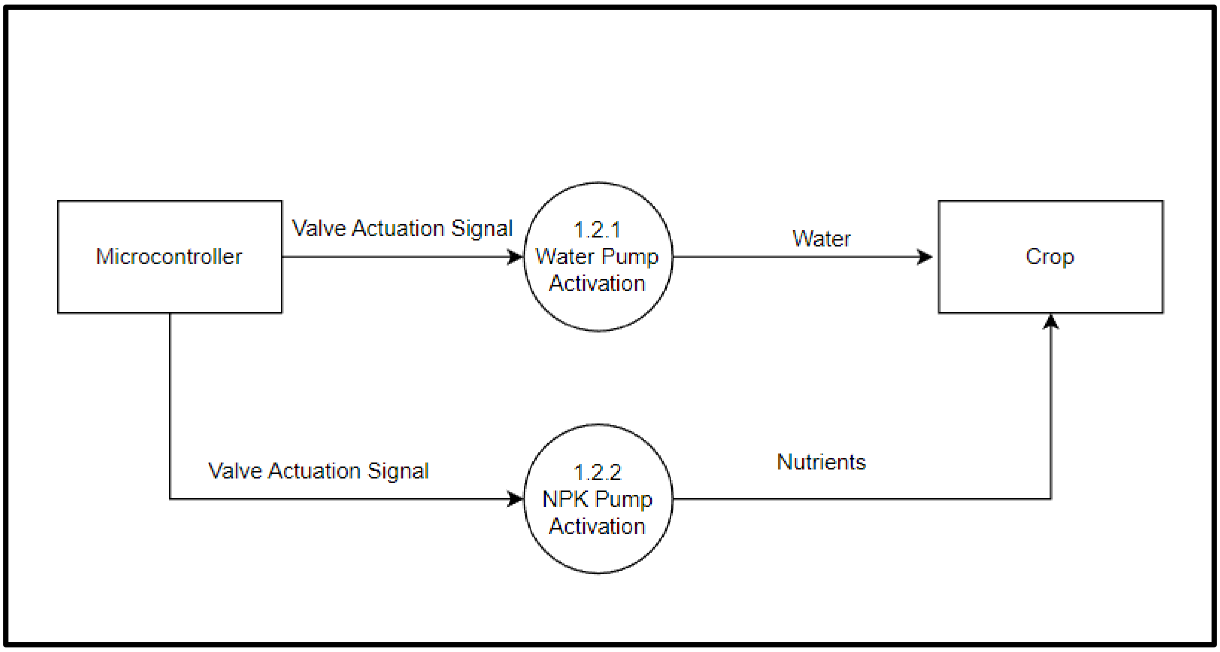

Fig 5.3.3: Level 2 DFD

6. Architecture Design: Tier-Architecture Diagram

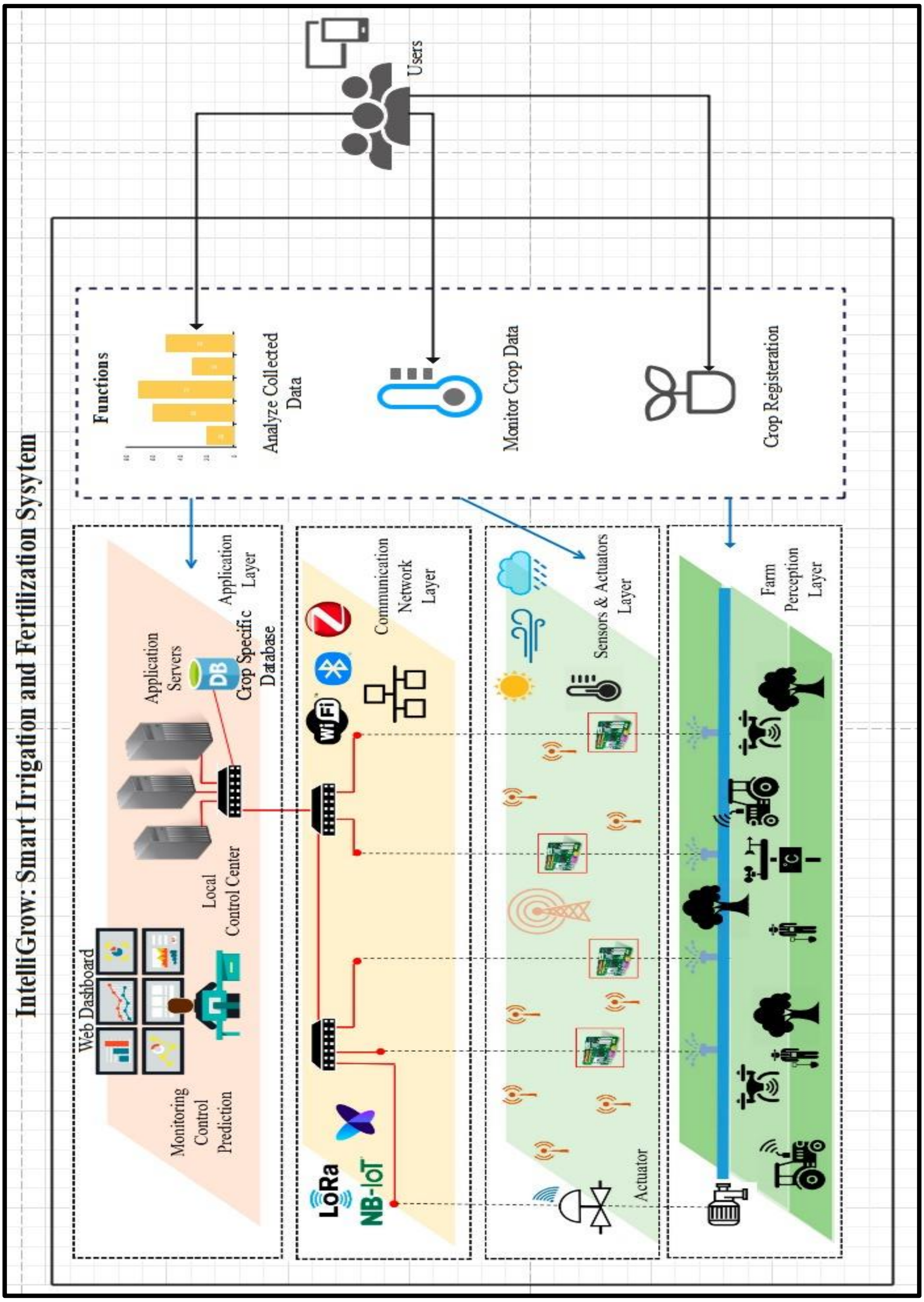

Fig 6: Tier Architecture for IntelliGROW

Fig. 6 depicts the Tier Architecture for IntelliGROW. The system is divided into four tiers that work together to provide the functionality.

The first tier is the Farm Perception Layer which forms the base for our system. It showcases 'where' the system is to be deployed and how the connections are laid through various connection pipes and pumps.

The second tier is the Sensor and Actuator Layer, which comprises various sensors (Soil moisture, temperature, humidity, water level, and NPK sensors) that are used and integrated into the system.

The Communication and Network Layer forms the third tier of the system. It consists of Wi-Fi modules that transmit the collected data from various sensors to the Control system for data analysis.

The fourth and final tier is the Application Layer, which analyses, controls, and displays the data. The control unit, via the communication layer, sends the control signal back to the valves and pumps to maintain the threshold levels in the soil. The user can analyse and visualize the data using a web dashboard.

Together, these four tiers make up the architecture of IntelliGROW, with each tier responsible for a specific aspect of the system’s functionality.

7. Cost Analysis

Since the system is hardware-heavy, the major expenditure will be buying various sensors listed below.

Equipment Required	COST
Rain Drop Sensor	₹180
Temp and Humidity Sensor	₹160
Flow Sensor Module	₹450
LDR Sensor	₹15
Water Level Sensor(for tank)	₹230
Raspberry Pi	₹4,000
Soil NPK Sensor	₹7,000
Mini Water Pump	₹150
1000RPM 12V Low Noise DC Motor	₹180
Solenoid Valve	₹300
ESP8266 WiFi Module	₹400
Miscellaneous Expenses	₹1,500
Total Cost	**₹14,565**

Fig 7.1: The Estimated Budget for IntelliGROW

Fig 7.2: Soil NPK Sensor

Fig 7.3: Raspberry Pi Module

Fig 7.4: Wi-Fi Module

Fig 7.5: Flow Sensor

Fig 7.6: Solenoid Valve