Abdullah Gul University

Department of Computer Engineering

Embedded Systems

AGRISENS **- Smart Agriculture System**

Instructor

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Introduction

In the backdrop of escalating challenges confronting the agricultural sector, the imperative for innovative solutions to enhance productivity and sustainability has never been more pressing. The proposed smart agriculture system represents a concerted effort to address these challenges by harnessing cutting-edge technologies to revolutionize traditional farming practices. Central to this endeavor is the integration of an extensive array of sensors, including soil moisture and water level sensors.

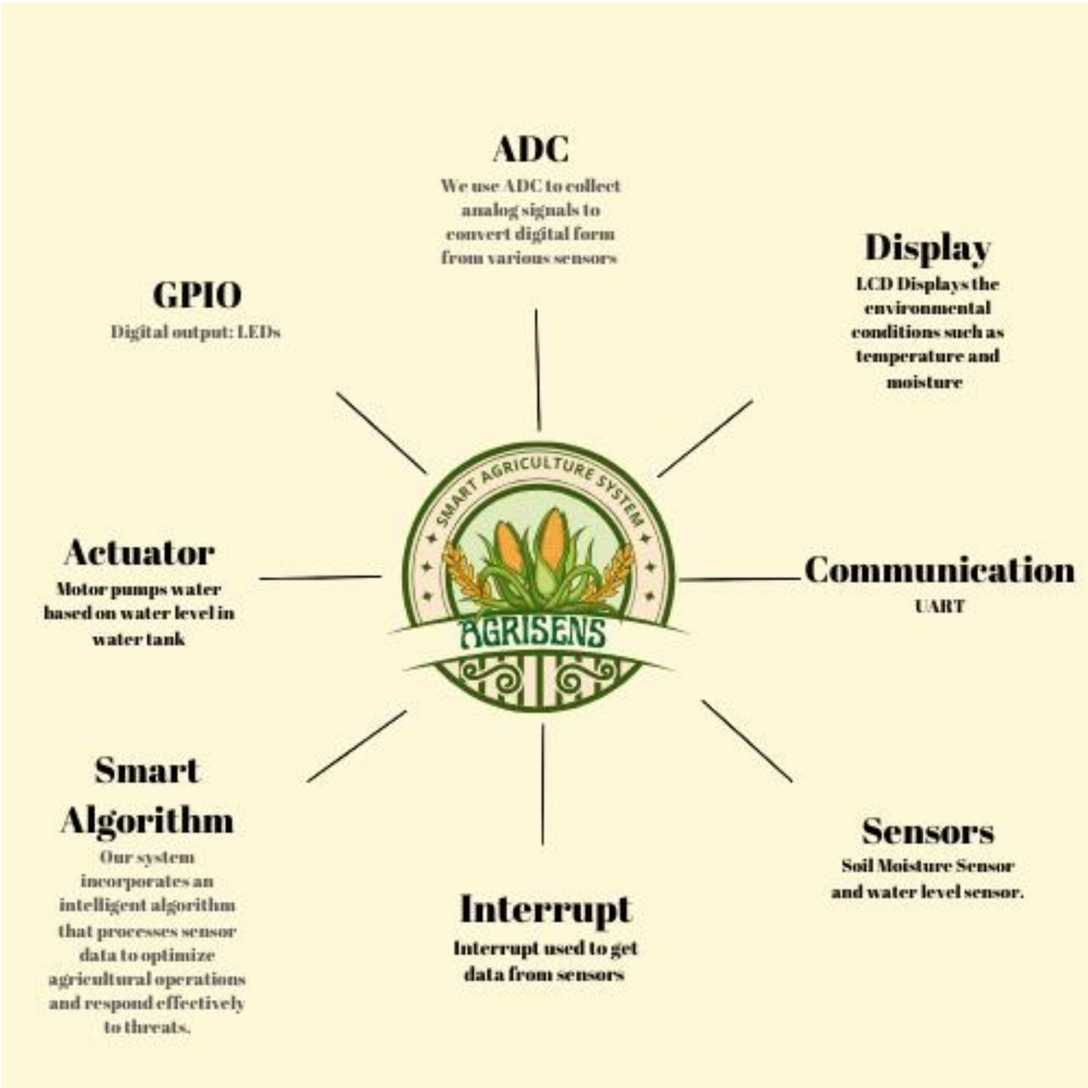
The seamless integration of these sensors facilitates real-time data collection, enabling the system to dynamically respond to changing environmental conditions. For instance, upon detecting indications of plant dehydration, the system autonomously activates the irrigation infrastructure to mitigate potential crop damage.

Moreover, the system boasts a user-friendly interface, comprising both an intuitive LCD display and a comprehensive terminal interface.

In conjunction with its data-centric functionalities, the system also incorporates an advanced irrigation infrastructure, complete with a water tank and water level sensor. This component plays a pivotal role in optimizing water usage by alerting users to replenish water level, when necessary, thereby ensuring the uninterrupted sustenance of agricultural operations.

Design

Features: Our smart agriculture system prioritizes the safety and efficiency of agricultural operations. To achieve this, we have implemented a range of features aligned with this goal. A network of sensors is deployed to promptly detect any potential hazards, ensuring the safety of crops and farm infrastructure. These sensors communicate alerts through various channels, including audible alarms via buzzers and visual notifications on displays.



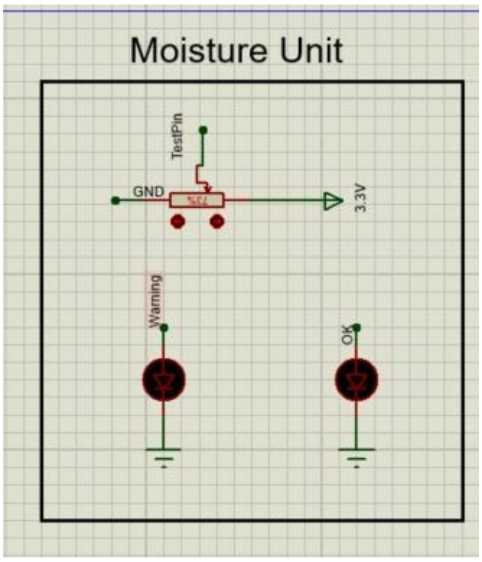
ADC: We used the ADC (Analog-to-Digital Converter) because the sensors in our project provide analog signals, which need to be converted into digital signals for the microcontroller to process. The ADC allows us to:

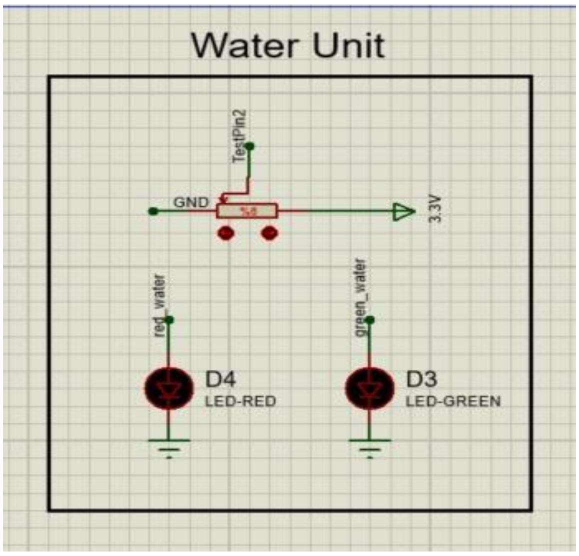
Accurately Measure Sensor Outputs: Convert the continuous analog signals from the soil moisture and water level sensors into discrete digital values that the microcontroller can read and process.

Real-time Monitoring: By using DMA with the ADC, we ensure continuous sampling and accurate monitoring of soil moisture and water levels without missing any data points.

Efficient Processing: ADC, combined with DMA, allows the system to handle sensor data efficiently, ensuring timely responses to changing conditions.

GPIO: GPIO LEDs serve as crucial indicators in our system, communicating important information to users. They signal emergency situations and provide status updates.
If the value in the soil moisture sensor is between 10-50, the green LED lights up; if a value other than these values is displayed, the red LED lights up.
If the value in the water level sensor is above 40%, the green LED lights up; otherwise, the red LED lights up.





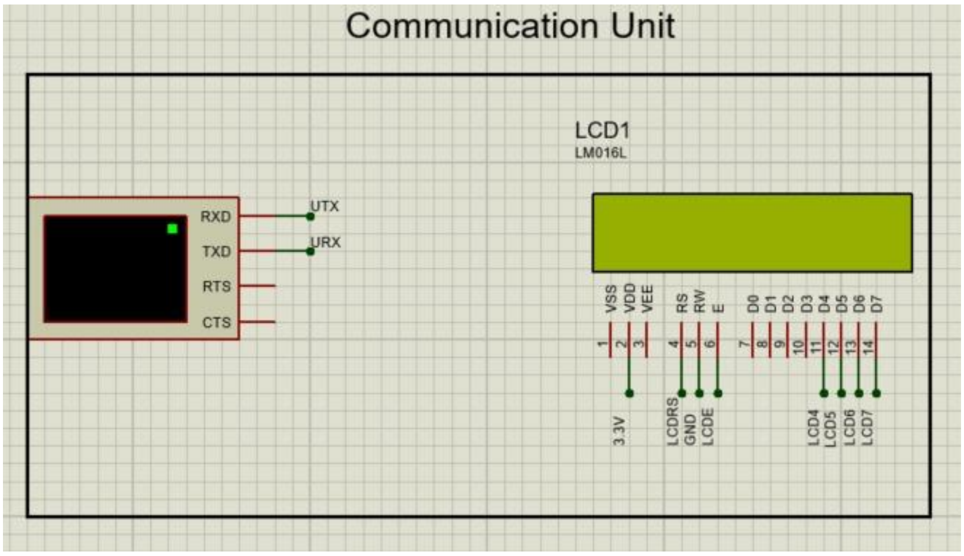
Interrupt: Interrupts are utilized for efficiently handling sensor data and external communications. They facilitate rapid response times by triggering actions in response to sensor inputs or external commands received via communication interfaces.

DMA (Direct Memory Access): In our project, DMA (Direct Memory Access) is used to handle the analog-to-digital conversion (ADC) process efficiently. In this project, real-time monitoring of water levels and soil moisture is critical. By using DMA, the ADC can continuously sample these values and store them in memory without missing any data points, ensuring accurate and timely responses to changes in water level and soil moisture.

Timer: We use timer for generating periodic interrupts to update the LCD display and toggle LED indicators based on sensor readings.

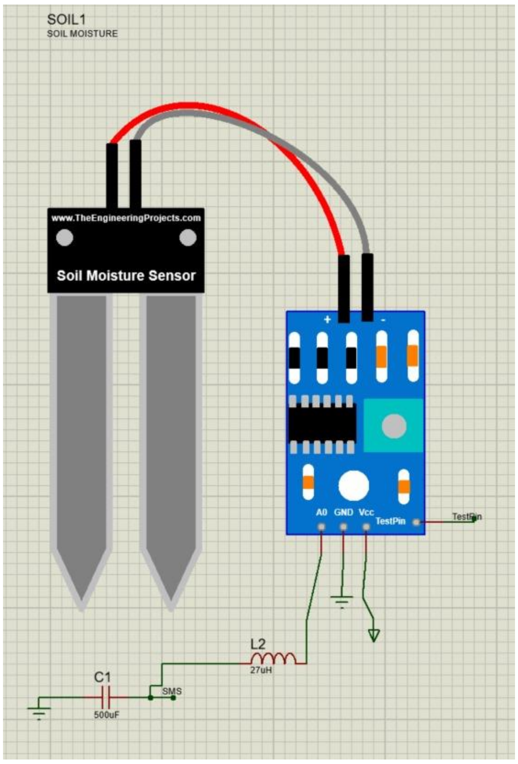
Display: LCD displays provide farmers with real-time information on crop health, environmental conditions, and system status. In emergencies, they display detailed alerts and instructions on mitigating risks to crops and farm infrastructure.
Thanks to the LCD, we can see soil moisture and water level values.

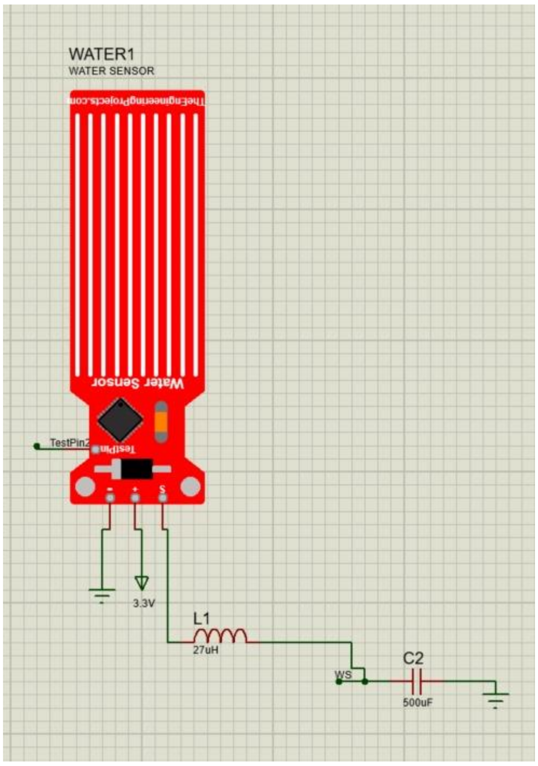
Communication: Communication between users and the system is established through various channels, including UART interfaces. Farmers can remotely access and control system functions using mobile applications, enabling them to monitor crop conditions and adjust irrigation schedules from anywhere.
In our project, when we write ‘w’ in the virtual terminal, LCD display shows us water level in the tank and when we write ‘m’ it shows moisture level.



Actuator: In our Agrisens project, an actuator is a crucial component that converts electrical signals into mechanical action. Specifically, the motor in our system acts as the actuator. The motor receives electrical energy and converts it into mechanical motion. This mechanical motion is used to drive the water pump, which is essential for irrigation.

Sensors: Our system utilizes a diverse array of sensors to monitor environmental parameters critical to crop health and productivity. These sensors include soil moisture and water level which continuously monitor conditions and trigger actions to optimize irrigation and crop management practices.





<u>Water Level Sensor:</u>
The water level sensor monitors the water level in the storage tank, which supplies water for irrigation. Maintaining an adequate water level in the tank is essential for the continuous operation of the irrigation system.

Functionality: When the water level in the tank is 40%, a green LED lights up, indicating a sufficient water supply. If the water level drops below this level, the red LED lights up to indicate that the water tank needs to be refilled.

Monitoring: The sensor provides real-time feedback on the water level, allowing users to ensure that there is always enough water available for irrigation. The visual indicators (LEDs) help users easily monitor the water level and take action when needed.

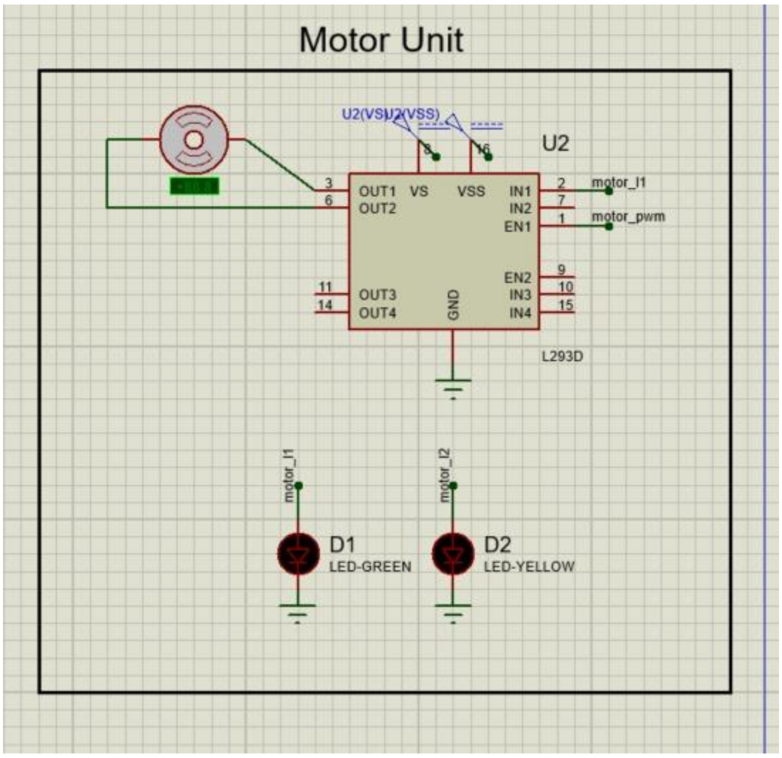
<u>Soil moisture Sensor:</u>
The soil moisture sensor measures the moisture content in the soil, which is crucial for plant health.The sensor provides real-time data on soil moisture levels, allowing the system to activate the irrigation process as needed.

Functionality: When the soil moisture level is between 10% and 50%, a green LED lights up, indicating optimal moisture levels. If the moisture level falls outside this range, a red LED lights up, signaling that irrigation is required.

Automation: The irrigation system is activated based on the moisture readings from the sensor. This ensures that the plants receive water only when necessary, preventing overwatering or underwatering.

Motor: The motor unit consists of a motor driver, dc motor and two LEDs (green and yellow) for indicating the motor's operational status based on the water level. The motor's speed is controlled by Pulse Width Modulation (PWM).

When Water Level between 20% and 40% The motor operates at normal speed. Only the green LED is turned on to indicate normal operation.
Water Level below 20%: The motor operates at twice the normal speed. The yellow LED and green led are turned on to indicate the motor is running at an increased speed.



Smart Algorithm: Our system incorporates an intelligent algorithm that processes sensor data to optimize agricultural operations and respond effectively to threats. In the event of an emergency, the algorithm issues warnings to farmers through designated channels and autonomously initiates corrective actions. For example, it may activate irrigation systems to mitigate drought conditions or adjust greenhouse parameters to optimize plant growth.

Challenges Faced During the Project

During the development of the Agrisens project, we encountered several challenges that required innovative solutions and a deep understanding of the technologies involved. Here are some of the key difficulties we faced and how we addressed them:

Simulation Performance
Slow Simulation Speeds:
Issue: One of the significant challenges was the slow performance of our simulation software. This made it difficult to quickly test and validate our designs.

ADC (Analog-to-Digital Converter) Challenges
Reading Multiple Sensors with a Single ADC:
Issue: Initially, we struggled to read values from two sensors using a single STM microcontroller. Our lack of experience with managing multiple sensor inputs via a single ADC complicated this process.
Therefore, we learned how to use the ADC's multiplexing capabilities to sequentially read data from multiple sensors.

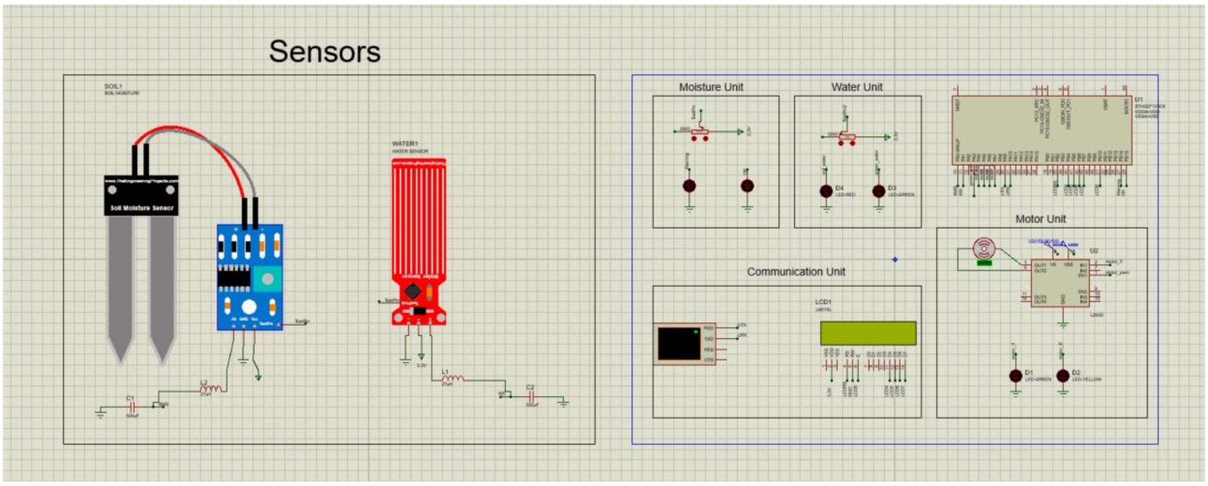
General Development Challenges
Learning Curve:
Issue: Our team initially lacked experience in certain areas, such as configuring and reading from ADCs and managing sensor data with a single microcontroller. Therefore, we invested time in learning and understanding these technologies. This included studying technical documentation, seeking guidance from experts, and experimenting with different configurations until we achieved the desired functionality.

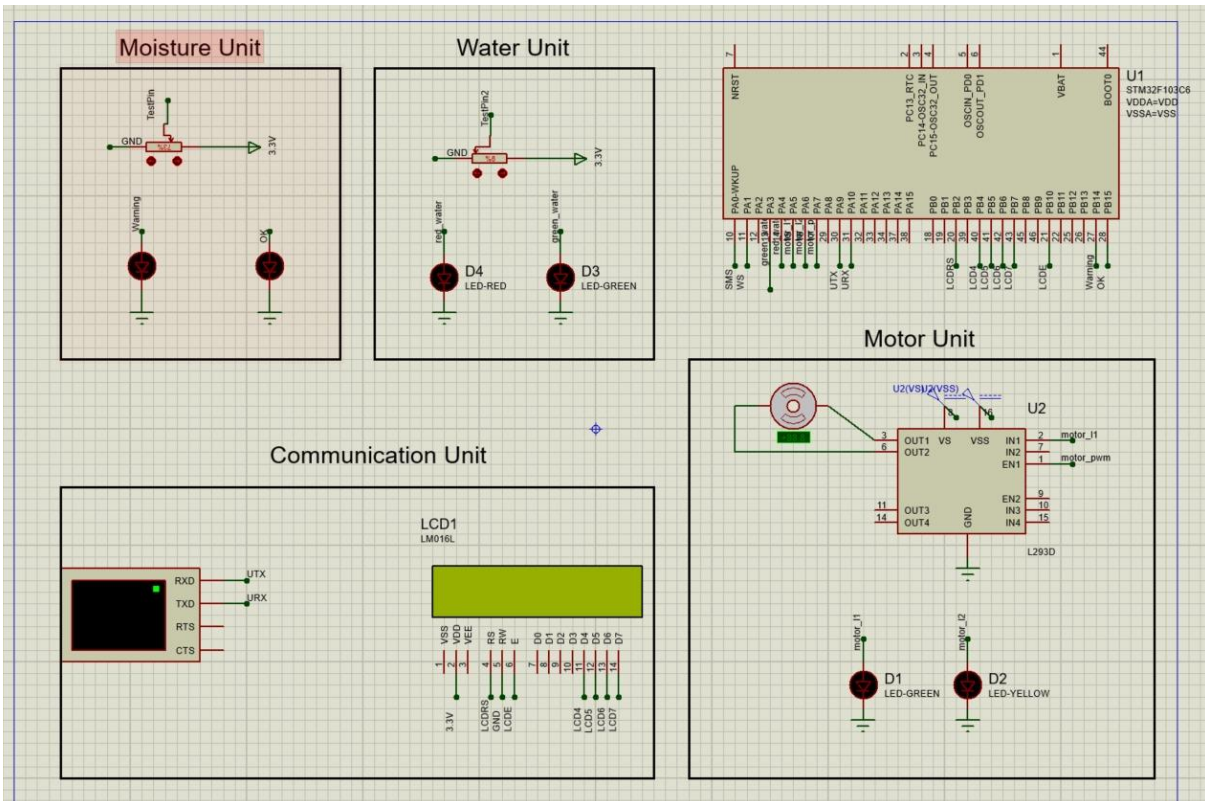
Future Planning

Building upon the foundation laid by our smart agriculture system, there are several avenues for future enhancements and expansions that we plan to explore:

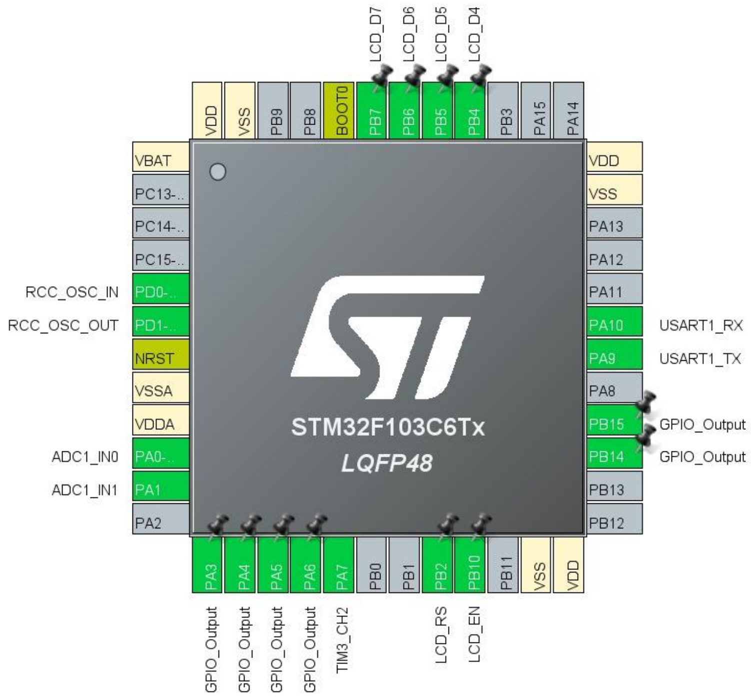
Smart Irrigation Techniques: Implementing drip irrigation and other advanced irrigation methods controlled by our system to further optimize water usage and reduce waste.
Rainwater Harvesting Integration: Incorporating rainwater harvesting systems to supplement water supply, promoting sustainability and reducing dependency on external water sources.
Enhanced User Interface and Accessibility:
Mobile Application Development: Creating a dedicated mobile app to provide farmers with real-time alerts, data visualization, and remote control capabilities, enhancing ease of use and accessibility.
Voice Control Integration: Adding voice command functionalities to the system, allowing farmers to interact with and control the system using simple voice instructions.

Project Screenshots


Sensors
Moisture Unit
Water Unit
Communication Unit
Motor Unit


Moisture Unit
Water Unit
Communication Unit
Motor Unit
U1
STM32F103C6
VDDA=VDD
VSSA=VSS
U2
L293D
LCD1
LM016L
D1
LED-GREEN
D2
LED-YELLOW
D3
LED-GREEN
D4
LED-RED

Cube MX



Tools We Utilized

Module/Feature	**We used these types:**
GPIO	• Digital Output ○ Push/Pull • Digital Input ○ Pull up
Communication	• UART ○ Interrupt
Interactivity (Leds, buttons, switches, touch etc.)	• Leds • LCD Display
Using sensors	• Sensor types ○ Soil moisture Sensor ○ Water Level Sensor
Actuators	• Motor
Timers	• TIM1 ○ PWM • TIM2 ○ PWM
Usage of Interrupts	• We used interrupts in: ○ checking thresholds of values from sensors
Error handling	• try catch
Analog-digital Converter	• multichannel • DMA

Advanced Things that no code is provided during the course	• LCD

CONCLUSION

The smart agriculture system outlined in this project represents a pivotal advancement in addressing the challenges confronting modern agriculture. By integrating cutting-edge technologies such as a diverse sensor network and an advanced irrigation infrastructure, the system aims to achieve several key objectives. Firstly, the system seeks to enhance agricultural productivity by providing farmers with real-time data on crucial environmental parameters. This enables proactive decision-making, such as timely irrigation, to optimize crop health and yield potential. Secondly, by optimizing resource utilization, particularly water, the system contributes to sustainability in agriculture. The efficient management of irrigation processes helps conserve water resources and mitigate the environmental impact of farming practices. Moreover, the user-friendly interface of the system ensures accessibility and usability for farmers, enabling them to interact with the system effectively. This empowers users to make informed decisions and adapt management practices according to their specific needs and preferences. In conclusion, the implementation of the smart agriculture system promises to yield tangible benefits for agricultural stakeholders. From increased productivity and resource efficiency to enhanced sustainability and user empowerment, the system represents a significant step forward in modernizing agricultural practices and ensuring the resilience of the agricultural sector in the face of evolving challenges.