Introduction to the organization

Modern Agri(Pvt)Ltd is a leading agricultural service provider operational in Sri Lanka. They offer a wide range of products and services with the aim of enhancing agricultural practices through new innovations and sustainability. The company supplies both Sri Lankan and regional markets with high-quality seeds, tools, greenhouse systems, irrigation technologies, and agri-consultancy that assist in the development of all processes in the agricultural supply chain. Modern Agri plays a major role in modernizing farmers with new advanced agricultural technologies while maintaining health and environmental standards.

Their operations span from small independent farms to national-level corporate projects by providing creative and reliable solutions for all budgets to clients looking for impartial and informed advice. Modern Agri has established its place in the market for combining traditional agricultural practices with modern technologies, focusing on improving crop productivity, profitability, and long-term sustainability.

They collaborated with global industry leaders, including the Rijk Zwaan company of the Netherlands, for seed technology. Modern Agri ensures that its customers receive the high-quality resources available in Israel, Europe, Thailand, China, India, and beyond. Their products include climate-controlled greenhouses, fertigation systems, water filtration systems, smart irrigation setups, crop supports, and a variety of technical agricultural components. The company also conducts training programs and meeting sessions with farmers & stakeholders with the aim of knowledge-sharing and field-level innovation, and familiarizing farmers with their products.

They have established research and development centers in the hill country and Kadawatha in which Modern Agri works closely with agricultural scientists and technologists to gain their knowledge and contribution to the company's new innovations. Modern agri is equipped with a diverse team of experienced individuals who have worked across the agricultural sector in Sri Lanka and beyond. Their experience in handling export-oriented farms, CSR farming clusters, and technologically advanced greenhouse projects makes them valuable assets for the company.

This collaborative, friendly, and innovation-driven environment provides us with an ideal foundation for the successful implementation of our IoT-based smart automated soil level monitoring system.

Project and Scope

Project overview

Modern Agri teamed up with us(X Solutions) to develop a smart IoT-based fertilizer monitoring system aimed at utilizing their greenhouse operations. Throughout the visit, there were issues identified within the organization. The biggest challenge faced is that they are relying on a completely manual process of fertilizing their plants. That results in Inconsistent nutrient application, poor crop performance, and challenges in yield predictability. Consequently, this limitation has had a negative impact on their future research activities. So the proposed solution aims at the automation of monitoring of essential soil and environmental parameters, regulating NPK fertilizer application automatically in order to crop yield enhancement, reduction of wastage of resources, and simplification of fertilization decision-making.

After discussing the project with the representatives of the organization, both sides agreed upon the project, which will take approximately 9 to 12 weeks, with the initial pilot targeted at greenhouse tomato cultivation.

Project Scope

The core scope of the project is to design, develop, and deploy a real-time monitoring and control system that automates fertilizer management based on soil conditions. The system uses the following parameters, which are critical to plant growth:

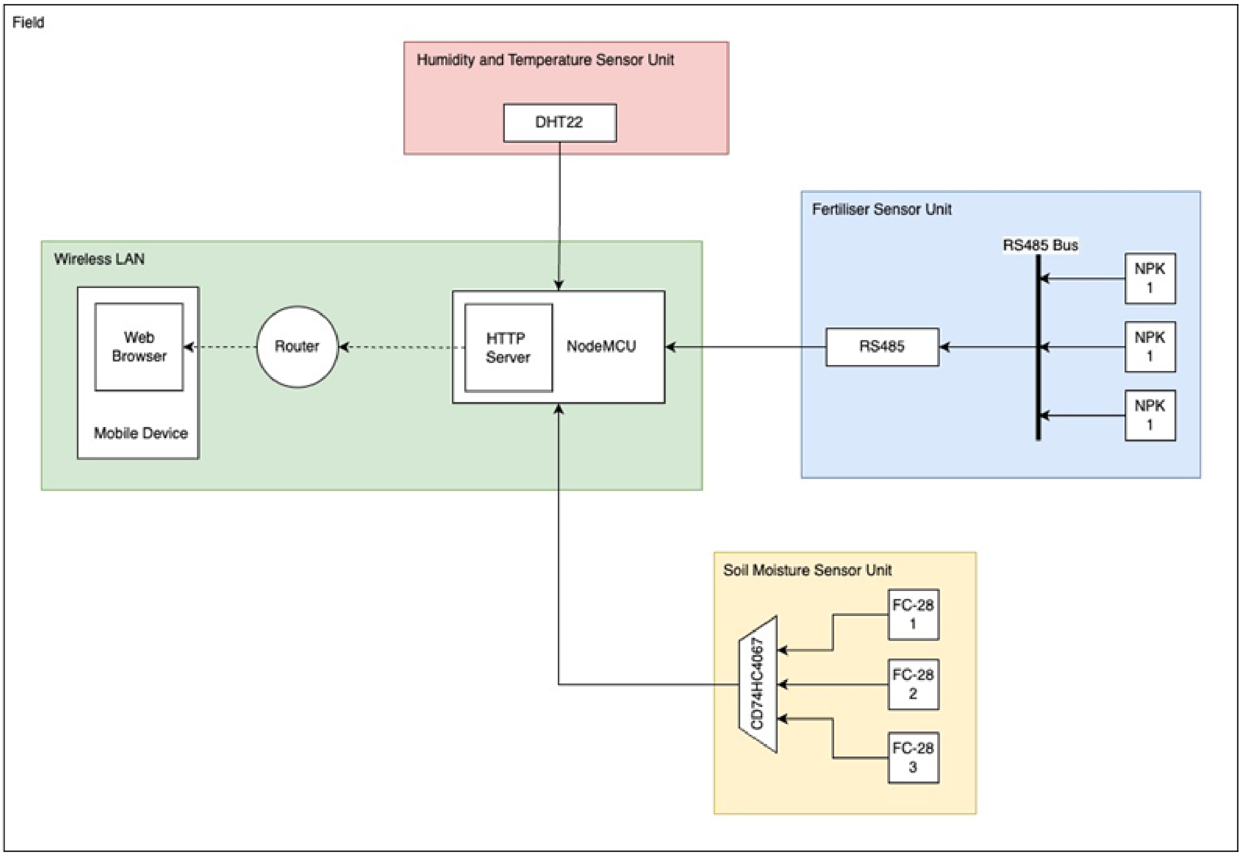
- Nutrient levels – Nitrogen (N), Phosphorus (P), and Potassium (K)
- Soil moisture
- Ambient temperature and humidity

Using the readings gathered through precise sensors, the system:

- Notifies farmers when soil or environmental conditions fall outside optimal thresholds
- Provides fertilizer recommendations aligned with real-time conditions
- Displays sensor readings via a browser-based interface connected through a local wireless LAN

<u>Design workflow</u>

The following diagram illustrates the system’s architecture, showing how each component is integrated.



This figure illustrates an IoT system for real-time monitoring of soil and environmental conditions using NodeMCU, sensor units, and Wi-Fi connectivity.

Hardware components

Component	Quantity	Function
NodeMCU(ESP8266)	1	Microcontroller with Wi-Fi; central controller
Wi-Fi Router	1	Creates a LAN for data transmission to browser
FC-28 Soil Moisture Sensors	3	Measure soil moisture in distributed zones
NPK Sensors	3	Measure Nitrogen, Phosphorus, Potassium levels
DHT22 Sensors	1	Monitors ambient temperature and humidity
RS485 Module	1	Handles long-distance communication with NPK sensors
CD74HC4067 MUX	1	Allows multiple moisture sensors on one analog pin

Casing,wiring	-	Physical protection and Connections

Library	**Purpose**
ESP8266WebServer	Hosts the web interface on NodeMCU
DHT	Reads DHT22 temp/humidity data
ModbusMaster	Reads data from NPK sensors via RS485
CD74HC4067	Multiplexes moisture sensors

- Arduino IDE is used for coding the NodeMCU.
- The firmware integrates sensor readings, decision logic, and server communication.

System Workflow / Communication Design

- The system operates as follows,
- Sensors collect data from the soil and environment
- NodeMCU receives and processes the sensor data
- Data is compared with ideal thresholds(gathered from the research) for tomato growth
- If values are out of range, alerts are shown via a browser interface(HTTP server)
- All data is transmitted over Wi-Fi for viewing on a mobile or desktop device.

Project Charter

Project Overview and Key Details

- **Project Name:** Smart Automated Fertilizer System for Efficient Crop Cultivation
- **Partner Organization:** Modern Agri (Pvt) Ltd
- **Project Type:** IoT-based agricultural system
- **Project Duration:** 13 weeks
- **Project Description:** This project is to develop an IoT-based fertilizer level monitoring system that monitors real-time soil and environmental conditions based on predefined thresholds. It aims to increase accuracy, reduce fertilizer and other resource wasteage, and improve crop yields mainly for tomato cultivation.

Roles and Responsibilities

Team Member	Role	Responsibilities
Member 1	Project Manager	Coordination, communication, timeline tracking
Member 2	Hardware Engineer	Sensor integration, circuit design
Member 3	Software Engineer	Microcontroller programming, data handling
Member 4	Data Analyst	Data modeling, threshold tuning, trend analysis
Member 5	UI/UX Designer	Interface design (if any dashboard is used), documentation
Member 6	Quality Assurance	Testing, system validation, feedback gathering

Project Vision.

To empower farmers with affordable, accessible, and user-friendly IoT technology that ensures optimal fertilizer application for sustainable farming.

Objectives:

- Monitor soil nutrients (NPK), temperature, humidity, and moisture in real time
- Automate fertilizer recommendations based on sensor data
- Improve crop productivity and reduce fertilizer wastage

- Offer a user-friendly system adaptable to low-resource environments

Business Need:
Modern Agri identified inefficiencies in the farmer's manual fertilizing process, which leads to inconsistent plant health, low crop yields, and low profits. A data-driven, automated monitoring system is needed to support better resource management.

Business Impact:
Our proposed system will improve the accuracy & efficiency of fertilizer use, reduce manual labor, and enhance productivity. It aligns with Modern Agri's mission to modernize traditional farming and supports the use of new technology in the agriculture of Sri Lanka.

Stakeholders

Stakeholder	**Role**
Modern Agri	Client and beneficiary of the system
Farmers	End users of the system
Project team	Designers,developers,testers
Research scientists	Advisors on plant requirements
System Engineers	Support for hardware setup

Key Deliverables

- IoT-based smart fertilization system (prototype)
- Sensor-integrated ESP32 module with data processing logic
- System documentation and user manual
- Pilot deployment on tomato plants
- Staff training and maintenance guidelines

Project Assumptions

- Availability of ESP32 and sensor modules in local markets
- Stable Wi-Fi access within the greenhouse for data communication
- Stakeholder availability for feedback and pilot testing
- The organization is open to future system enhancements

Project Constraints

- Limited budget, as the system is designed for low-income farmers

- Tight 13-week timeline from development to deployment
- Environmental conditions may vary and impact testing
- Team availability is limited to academic schedules and coursework

Project Risks

Risk	Mitigation
Sensor failure or inaccuracy	Use of calibrated, high-accuracy modules and redundancy tests
Communication issues (Wi-Fi/Modbus)	Conduct range testing; backup wired protocols available
Component unavailability	Use local suppliers and have alternative component lists
Time overruns	Weekly progress tracking and task delegation

Functional Requirements:

- Real-time monitoring of NPK, moisture, temperature, and humidity
- Automated response logic for fertilizer decisions
- Data transmission from the field to central controller

Non-functional Requirements:

- Ease of use for non-technical users
- Low cost of deployment
- Compatibility with greenhouse environments

Success Criteria:

- 90 %+ accuracy in nutrient level detection
- Successful pilot deployment with positive stakeholder feedback
- Reduction in fertilizer usage and an increase in yield after deployment
- System stability in real-world testing conditions

Project Life Cycle

The project life cycle has various phases that a project goes through from start to completion. It is beneficial as it offers project managers a structured approach that helps with planning, execution, and control. While there are many different versions of the project life cycle, the most common one is divided into five stages, including initiation, planning, execution, monitoring and control, and closure.

1. Project Initiation Phase

The initiation phase of our project involves identifying a real problem in collaboration with the selected agricultural organization, Modern Agri**.** First, we visited the organization, and there we had a discussion with a managerial-level representative of the organization. We observed that their current fertilizing system had several issues, like they could not identify the soil Nitrogen, Phosphorus, and Potassium levels separately, causing fertilizer wastage and increased operational and initial costs. After recognizing these issues, we designed a smart fertilizing system that takes real data from the soil sensors to optimize fertilizer application. Our solution is to improve crop health, reduce labor dependency, and enhance efficiency in farming. After presenting our proposal to the lecturer with the proof of our visit, the project was reviewed and officially approved, marking the successful completion of the initiation phase.

2. Planning phase

During the planning phase, we focused on defining the project scope, objectives, and methodology approaches required to implement the smart fertilizer system. In this phase, we did the requirement analysis and designed the solution for the smart fertilizer system. We clearly understood the requirements of the organization. The requirements can be categorized into two parts like functional requirements and non-functional requirements. Functional requirements like real-time soil monitoring and wireless data transmission, and non-functional requirements like reliability and cost effectiveness were focused on this phase. We designed the system architecture using suitable components, including the Node MCU, NPK sensors, moisture sensors, and a DHT sensor for environmental monitoring. Designing also includes both hardware and software specifications used in the system. We also considered the budget estimation for the proposed system in the planning phase.

3. Execution phase

The execution phase marked the transformation of our project plan into a working prototype of the smart fertilizing system. During this phase, we focused on hardware implementation as well as software implementation. We began with the hardware assembly, integrating key components such as the NodeMCU microcontroller, NPK sensors, soil moisture sensors, and a temperature and humidity sensor (DHT22). To ensure seamless communication across the system, we are integrating an RS-485 module for reading fertilizer sensor data and an analog multiplexer (CD74HC4067) to manage multiple moisture sensors using limited input pins. All components are connected correctly and enclosed to secure the setup from environmental conditions.

Once the physical system is partially completed(sufficient to develop software on that), we will start the software implementation phase. Using the Arduino IDE, we are programming the NodeMCU to interpret the incoming data from sensors. Then we utilize various software libraries to support the functionalities. At the end of the execution of these software and hardware implementation phases, our prototype will be fully assembled and programmed to read real-time data from the environment, interpret that data, and make it accessible to users through a simple local web interface.

4. Monitoring and controlling phase

The monitoring and controlling phase helped us to ensure that the smart fertilizing system works efficiently and gives accurate results. Under monitoring, the conditions of the soil and the environment are tested by using the sensors. All this data is sent to the Node MCU microcontroller. Controlling means taking actions based on the sensor data. Users can see live data and control the system from system from a computer or a mobile phone.

Before using the system in a real farm environment, we did hardware tests to make sure all the sensors, wires, and devices were connected properly and were sending accurate data. After that, we did software testing to ensure the program worked correctly. Finally, we did a pilot test in a small area of the farm to try the full system and to see how it works in a real farm environment. These tests helped us to fix some small issues and improve the system.

5. Closure phase

The closure phase is the final stage of our project. Here we officially completed all the activities related to the project and handed over the project to the organization. After finishing the implementation, we carefully reviewed the system to ensure that it meets the requirements of the organization. Then we did a final testing to confirm that all the sensors and the software programs work properly, providing accurate data and function efficiently and smoothly. All the project documents, including the user manual, project reports, source codes, and instructions for future use, were handed over to the organization with the smart fertilizing system. We also did some training sessions for the users in the organizations to explain how to use the system independently. During this phase, our team members had a discussion regarding the success of our project and how we faced the challenges we had to face during the project. This phase helped us to learn valuable lessons in teamwork, problem solving, and project management. The project closure ensured that the project was completed successfully and effectively to the satisfaction of the client. After completing the closure phase now the smart fertilizing system is now ready to be used in the day-to-day agricultural needs of the Modern Agri organization, increasing crop health and productivity with the effective use of fertilizers.

<u>Work Breakdown Structure (WBS)</u>

Phase 1: Getting an Overview of the Tomato Cultivation Process (Week 1)

1. Visiting the organization
2. Identifying the solution to the problem
3. Identifying optimum conditions for plant growth

Phase 2: Requirement Analysis and Planning (Week 2)

1. Identifying parameters
2. Gathering requirements
3. Defining the project scope
4. Outlining technical specifications
5. Validating with stakeholders

✅ Project plan completed

Phase 3: Designing the IoT Solution (Week 3)

Selecting appropriate sensors

1. Identifying module specifications
2. Circuit design
3. Final design approval
4. Validating with stakeholders

✅ Solution design completed

Phase 4: Hardware Implementation (Week 3–4)

1. Connecting & mounting sensors
2. Soldering
3. Providing a necessary power supply
4. Ensuring the physical protection of components

Phase 5: Hardware Testing (Week 4–5)

1. Testing sensors individually
2. Power stability check
3. Long-range communication test
4. Adjusting sensor sensitivity

✅ Hardware phase completed

Phase 6: Software Implementation (Week 4–6)

1. Microcontroller programming
2. User interface development
3. Integration with hardware
4. Validation with stakeholders

✅ Software phase completed

Phase 7: Software Testing (Week 5–7)

1. Sensor-to-microcontroller communication test
2. Integration testing
3. Wi-Fi connectivity testing
4. Code debugging

Phase 8: Launching the Pilot Project (Week 8)

1. IoT system installation on a sample plant
2. Performance monitoring
3. Identifying and addressing issues

Phase 9: Deployment at Enterprise Level (Week 8–9)

1. Large-scale deployment
2. Proposing solutions for long-term improvements

Phase 10: Staff Training and Maintenance (Week 8–9)

1. Conducting staff training sessions
2. Discussing the system maintenance plan with management

Time schedule

Our project follows a hybrid methodology, combining Waterfall for the main project phases and Agile for managing subtasks within each phase. The Waterfall model ensures a structured flow, while Agile sprints allow flexibility and iterative improvements. Below work-breakdown is documented in the form of user and story, found agile methodology.

Phase	**Description**	**Start date**	**End date**	**Duration**
Phase 1	Overview Study	Feb 23	Feb 29	1 week
Phase 2	Requirement Analysis	Mar 1	Mar 7	1 week
Phase 3	Solution Design	Mar 8	Mar 14	1 week
Phase 4	Hardware Implementation	Mar 15	Mar 21	1 week
Phase 5	Hardware Testing	Mar 22	Mar 28	1 week
Phase 6	Software Implementation	Mar 22	Apr 4	2 weeks
Phase 7	Software Testing	Mar 29	Apr 11	2 weeks
Phase 8	Pilot Project	Apr 12	Apr 18	1 week
Phase 9	Enterprise Deployment	Apr 19	Apr 25	1 week
Phase 10	Training & Maintenance	Apr 26	May 4	1 week

<u>Strategic Management Process</u>

The strategic management process for the *Smart Automated Fertilizer System* was guided by clearly defined objectives, proactive planning, and continuous feedback mechanisms.

Vision – To revolutionize smart agriculture by ensuring precise, efficient, and sustainable fertilizer application by using affordable and accessible technology for sustainable crop growth.

Mission – To develop and deploy an automated, data-driven fertilizer system using IoT technology to monitor soil nutrients and support efficient farming.

Environmental analysis(SWOT).

Strengths: Accurate nutrient detection and reduced human error. Cost effectiveness and real-time data collection

Weakness: Limited initial scalability, dependent on wi-fi availability, requires basic technical training.

Opportunities: Government support for technology-driven agriculture, rising internet in smart farming, and potential to improve multiple crop support.

Threats: Resistance to change from traditional agriculture methods, hardware supply chain issues, harsh environments, and severe weather conditions.

Strategy formulation

The strategic approach of this project aimed at creating an affordable, scalable solution that bridges the gap between traditional farming and modern technology.

- Our primary goal is to introduce an affordable device for farmers.
- Providing real-time information that can be accessed from mobile devices.
- Targeting mid-sized farms and middle-level farmers.

Strategy implementation

1. A Gantt chart has been developed for each and every phase of development.

2. Creating the device using Arduino ESP 32, various sensors, cloud platforms, and LAN technology.
3. As the last phase of the project, there is a training session for consumers.

Strategy Evaluation and Control

In order to ensure performance, quality, and stakeholder satisfaction:

- Consumers can gather information using the cloud platform. From this data consumer can measure the accuracy of the data manually(if needed).
- There is a feedback mechanism from farmers. With this feedback development team can improve their next batch.
- Internal testing and pilot deployment helped identify and rectify early issues. From that, it reduces the risk of errors in enterprise-level deployment.
- Upon successful implementation, the development team intends to upgrade the system for complete automation of the fertilizer distribution process

This strategic approach not only ensured the project was executed effectively but also positioned it for long-term impact and scalability within Sri Lanka’s evolving agricultural landscape.

Financial analysis

Hardware cost

Device	
Node MCU	Rs.1690
Router	Rs.5000
Moisture level sensor 3x	Rs.1080
NPK sensor 23000x3	Rs.69000
DHT(T&H) x1	Rs.490
RS485(NPK data receiver)	Rs.1300
CD74HC4067(Analog mux)	Rs.480
Wiring + soldering	Rs.5000
Casing	Rs.3000
Total Estimation	Rs.88950

Software and cloud services

Free-tier cloud services were utilized during the development phase.

Development and labor costs

Developer cost – As a university project, no cost for developing

Testing – Rs.. 15000 (transport cost included)

Maintenance and future upgrade estimates

System scaling and automation – Rs 35000

Replacement parts (Because sensors have a limited life span) – Rs 15000

Total cost summary

Category	Estimated cost (LKR)
Hardware components	88950
Devolopment and testing	15000
Maintenance and upgrade	50000
Total estimated budget	153590

Conclusion

This project has demonstrated how our innovative IoT solution modernizes the traditional tomato cultivation process. By developing the Smart Automated Fertilizer System, we have addressed a critical inefficiency faced by farmers in the monitoring of plant growth. Through our project, we have delivered an accurate data-driven, sensor-based solution that aligns with Modern Agri’s goal of promoting sustainable, productive farming across Sri Lanka.

Our work successfully proves the goal of our project, which is integrating real-time environmental and soil monitoring with automated fertilizer control by improving efficiency, accuracy, and overall agricultural outcomes. Our system supports timely and accurate fertilizer delivery and also empowers decision-making through centralized data collection and trend analysis for future forecasting.

By the completion of this project, we contributed to the modern agricultural improvement of this country by providing a functional, scalable IoT solution aligned with real-world conditions. Real-time monitoring not only reduces human error but also ensures that crops receive the right type and amount of fertilizer at the right time. Our collaboration with agricultural experts, other stakeholders, and field visits to Modern Agri helped us to develop a solution that is well-relevant and grounded in practical scenarios. Every phase, from planning, designing, to testing and even the stakeholder training, we completed them with an emphasis on usability, adaptability, and impact. We applied project management principles to navigate through distinct life cycle phases.

A key strength of our solution is its exceptional cost-effectiveness, which makes it user-friendly for low-income and small-scale farmers. More importantly, the system’s user-centric design ensures ease of use, enabling farmers with limited technical knowledge to operate and maintain it with minimal training. Since our primary focus was low & middle-income farmers, we intentionally prioritized affordability, accessibility, and simplicity over high-end automation.

While our solution has successfully achieved our goals, it can be improved with more enhancements such as AI-based predictive analytics, cloud-based dashboards, and an automated fertilizing system using robotic technology. As the country's economy is growing and with the help of government loan schemes, these advanced features can be introduced incrementally, enabling farmers to gradually adopt more sophisticated capabilities without overwhelming their financial or technical resources.