Farm Project Proposal

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Collaborative farm Proposal Cover letter

We are excited to present our project proposal, which involves the implementation of an automated data collection system for organic farm harvest data. This initiative is a collaborative effort between the Computer Science Department and the Organic Farm's Principles of Farming class at Evergreen State College. The primary objective of this project is to upgrade the new wash station with the necessary technology to facilitate automated data collection of harvest data.

Specifically, our project aims to collect the weights of harvested items, categorized into four main groups: "To Market," "To Student Services," "Cull," and "Value Added." The "To Market" items are of marketable quality and will be sold at the student-led organic farm stand. "To Student Services" items, although visually imperfect, are still of fair condition and will be provided to student services for free distribution. The "Value Added" category includes items that, while edible, are severely bruised and require transformation, such as turning bruised apples into apple butter. The "Cull" items are unsuitable for human consumption and will be composted to nourish future crops.

The technical details of the data collection system are outlined in the design document. In summary, weight data from scales will be fed into a Raspberry Pi and displayed on a screen. Categorization will be managed using barcode scanners to ensure speed and accuracy, akin to retail inventory tracking systems. We have prioritized ease of maintenance and durability in our hardware selections, allowing for minimal upkeep. When maintenance is necessary, the required off-the-shelf parts are detailed in the Bill of Materials and design document. Over the next quarter, we will develop a maintenance guide that is user-friendly enough to be managed by freshman CS students if there is interest. Another option for long term maintenance is to use front desk workers, this would be a way to increase community engagement and make the ACC more vibrant and see increased usage. The maintenance document will be engineered for ease of maintenance.

Our system is designed with long-term objectives in mind. While nothing is entirely future-proof, this setup is highly resilient to future developments. Utilizing a Raspberry Pi as the central hub allows for connectivity with hexapod robots, sensory hubs for monitoring soil moisture and nitrogen levels, and machine vision weed detection.

This comprehensive data collection will enable the organic farm to make informed farming decisions. In the immediate term, the harvest data will guide the farm in selecting the most financially sustainable crops. Looking ahead, with potential regenerative farming faculty, hexapod robots could monitor weeds and pests, aiding in the strategic release of chickens to control pest insects. Continuous soil nutrient monitoring through sensor clusters in the micro controllers class will provide farm students with a more detailed understanding of soil conditions beyond intermittent lab measurements.

All collected data will be open source, benefiting not only Evergreen State College students but also local businesses and other agricultural science departments. In 1975, students laid the foundation for the farmhouse; in the 2024-2025 school year, let students lay the foundation for a modern farm that will serve for the next 50 years.

Thank you for considering our proposal. We look forward to your support and collaboration on this trans-formative project.

Sincerely,

Students of the All Organic farm-Computer Science Collaboration team.

Evergreen State College

Project Outline

Project Overview

The proposed project aims to streamline the collection of harvest weights across four main categories:

- **To Market:** Items of high quality, ready for sale at the student-led organic farm stand.
- **To Student Services:** Items with visual defects, donated to student services to provide free food for students.
- **Value Added:** Items that, though severely bruised, can be transformed into products like apple butter.
- **Cull:** Items unfit for human consumption, returned to compost for enriching the next crop cycle.

Data Collection System

The automated data collection system will feature:

- **Weight Measurement:** Weight data collected from scales will be processed using a Raspberry Pi and displayed on an interface screen.
- **Categorization:** Bar code scanners will categorize items swiftly and accurately, akin to retail inventory systems.
- **Hardware Considerations:** The selected hardware prioritizes ease of maintenance and durability, ensuring minimal need for repairs and straightforward replacement of parts as listed in the Bill of Materials and design document.

Future-Proof Design

Our system is designed to be highly adaptable, enabling future integrations such as:

- **Hexapod Robots and Sensory Hubs:** For monitoring soil moisture and nitrogen levels.
- **Machine Vision Weed Detection:** To optimize pest control and farming decisions.
- **Nutrient Sensors:** Providing continuous, granular data on soil quality.

Implementation and Maintenance

Over the next quarter, we will develop a comprehensive maintenance guide as we deploy our Data Collection System. designed to be user-friendly for freshman CS students or Evergreen College IT staff. The long-term vision includes integrating advanced technologies to support regenerative farming practices and open-source data sharing to create ties with farms in industry and other Agricultural science departments.

Project Roster

This project would not be where it is today without the support of all these driven individuals. Thank you, everyone. A special thanks to all the faculty who provided letters of support.

Faculty support

Paul Pham, Ph.D., Computer Science

I teach upper-division computer science courses, including Data Structures & Algorithms (DSA), '23-'24. In '24-'25, I'll also be teaching in Advanced Computing & Machine Learning with Applications to Biology (ACMLAB).

In Fall '24, DSA students and I collaborated with Melissa Nivala and Principles of Farming (POF) students to begin designing a data automation and analysis system for Evergreen's Organic Farm. This project is part of a long-term, interdisciplinary effort that will support team-taught Coordinated Studies Programs, provide long-term benefits to the College through durable equipment and sustainable food systems, and give students opportunities for research and publication.

In Winter '25, I'll lead a Student-Originated Studies (SOS) program focused on farm automation. This program will include students from CS, farming, and engineering, with clear design goals and user feedback from farm students. In Spring '25, ACMLAB will include a hexapod robotics project with a camera and software to analyze 3D models of plants. This work will support interdisciplinary teaching with biology and CS faculty (Catherine Kehl and Pauline Yu). We aim to explore how Evergreen can integrate CS with natural and agricultural sciences without compromising the success of the existing CS curriculum. Our farm's expansive land and flexible, self-driven student culture provide a unique advantage for this effort, aligning with the College's goal of increasing enrollment by 1,000 students.

In '25-'26, I'll teach evening PaCE courses focused on back-end development and maintaining web services for farm automation. A compelling website and online presence can be designed by students taking front-end courses with faculty like Jes Carey and Arlen Speights. Additionally, I'll assist in a faculty search for a DSA and SOS visiting hire for the Olympia curriculum. The role will emphasize farm collaboration as a unique intellectual and service-oriented opportunity. This may align with the Regenerative Agriculture hire, who has shown interest in using technology and data in their research.

I look forward to advising and helping design sustainable engineering processes for this and future SOS programs and collaborating with faculty and students at Evergreen.

Paul

Melissa Nivala, Ph.D. Applied Mathematics

I am a core faculty member of the Food and Agriculture pathway, focusing on quantitative analysis. In Fall 2024, while teaching Practices of Organic Farming (POF), the lack of data (collection, transfer to electronic format, and transparent sharing) was identified as a key bottleneck, impeding the ability of students to learn through a quantitative framework. Thus, I am heavily dedicated to this collaborative project and will continue to support it throughout the 24-25 academic year and beyond.

My contributions in Winter and Spring '25 will be advising DSA students in the nature of the data, i.e. data management: what variables need to be measured, which units and unit conversions are necessary, and how to best disseminate the data for analysis to inform farm operations and curriculum. I will co-teach a Student Originated Studies program with Paul Pham, and plan to visit the farm and the DSA students regularly to ensure success of the project. I will strive to make the data transparently available, via a website or online repository, so it can be used as a teaching tool in any program containing mathematics, statistics, food and agriculture.

Longer term, I am heavily involved in the curriculum planning for the next two academic years of farm curriculum and will be teaching on the farm in '25-'26 and '26-'27. This data management project will set the stage for faculty to be able to develop rigorous, scientific learning on the farm, ideally resulting in student led research projects and upper division science credit offerings. The plan to collect data strongly aligns with the onboarding of a new faculty member in Regenerative Organic Agriculture, supporting the new faculty in teaching advanced soil science, quantitative agroecology, etc. and conducting undergraduate scientific research. I plan to collaborate with this new faculty on undergraduate research, to develop mathematical models of nutrient cycling, plant and organism growth and other concerns for regenerative agriculture. Development of these models will require fine grained data collection, which is the main goal of this current project.

Thanks,
Melissa

Students

Following the esteemed faculty who guide and shape the academic journey with their vast expertise and knowledge, we present our talented and ambitious students. This section is dedicated to those who are embarking on their path to greatness, ready to learn, grow, and make their mark on the world.

Austin Strayer

STEM student Senior – Data structures and Algorithms – Software development, and data architecture.

Dani Monroe

STEM student Sophomore – Data structures and Algorithms – Leadership, Data science and, applied computational modeling

Leif Mark George Fischer II

STEM student Junior – Principals of farming – Agricultural Ecology, and Indigenous land practices *this project bloomed from your idea*

Shawn Bird

STEM student Sophomore – Data structures and Algorithms – Technology Consulting

Farm Diagram

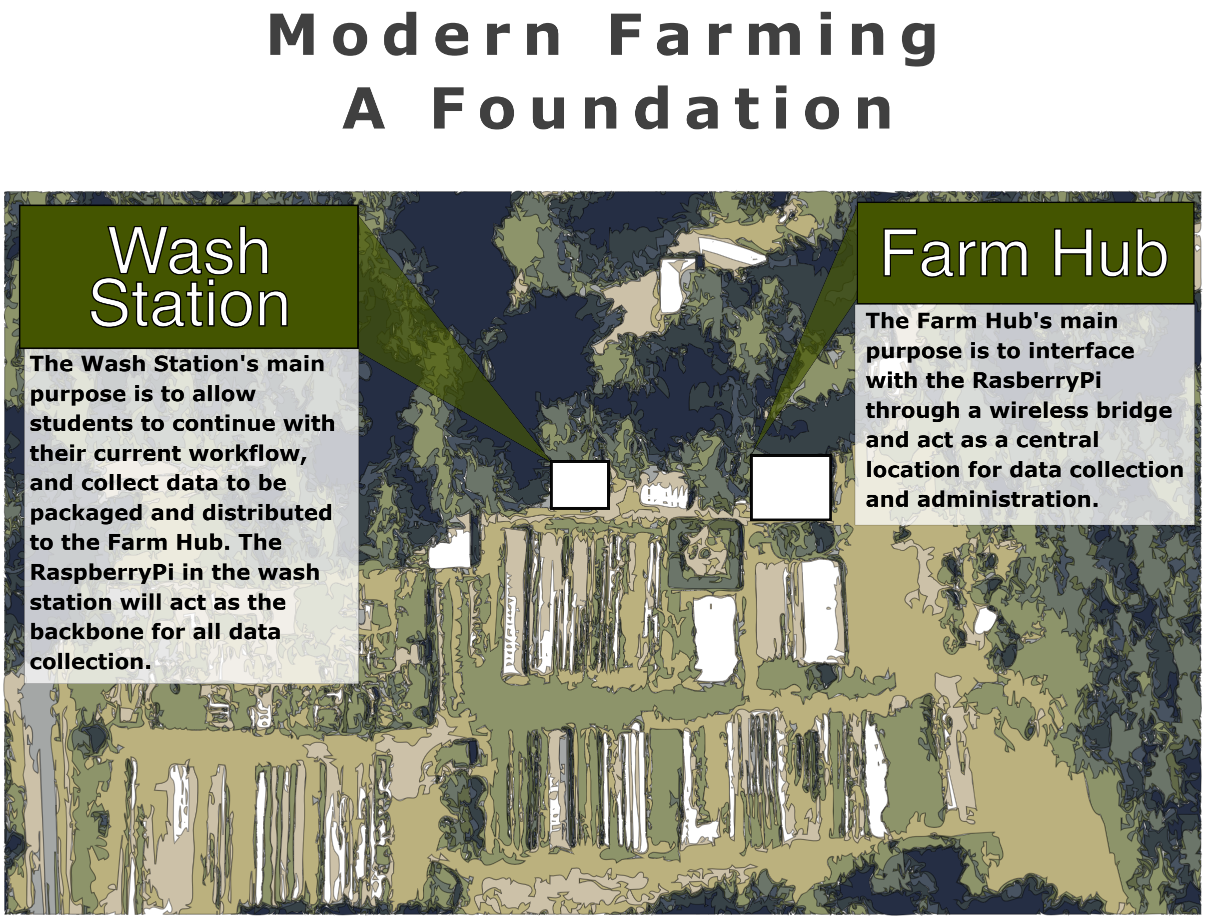

Figure 1: 10k foot view of the organic farm

Network Diagram

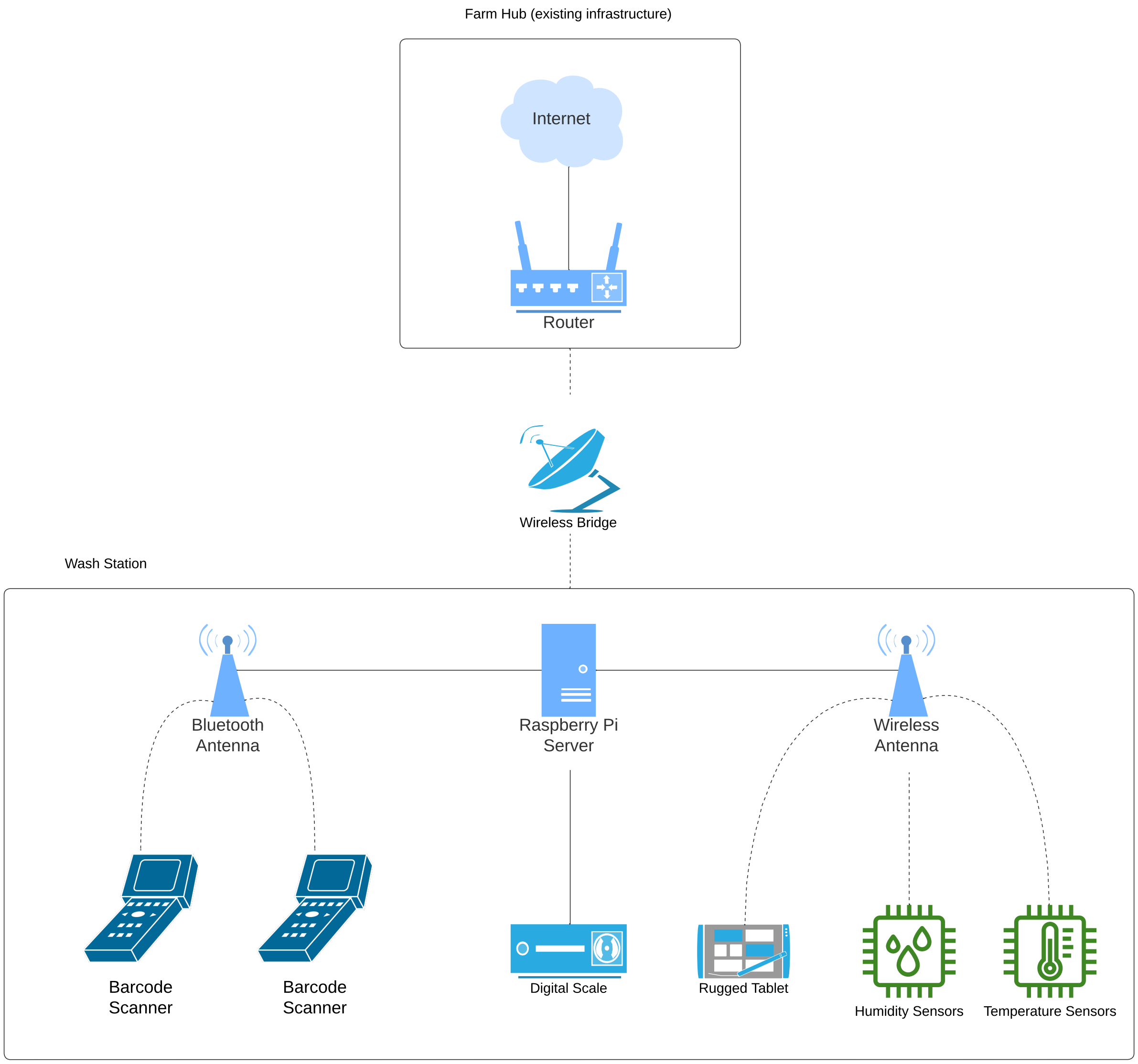

Figure 2: Data connections between devices

Server Diagram

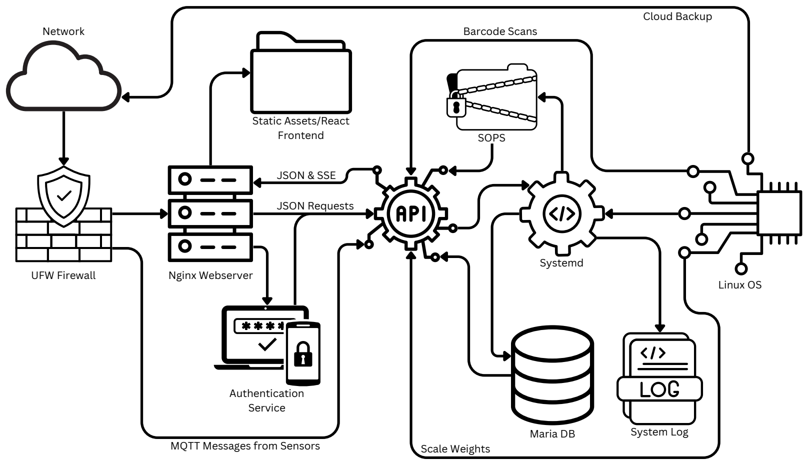

Figure 3: Diagram of the Raspberry Pi server

Data Diagram

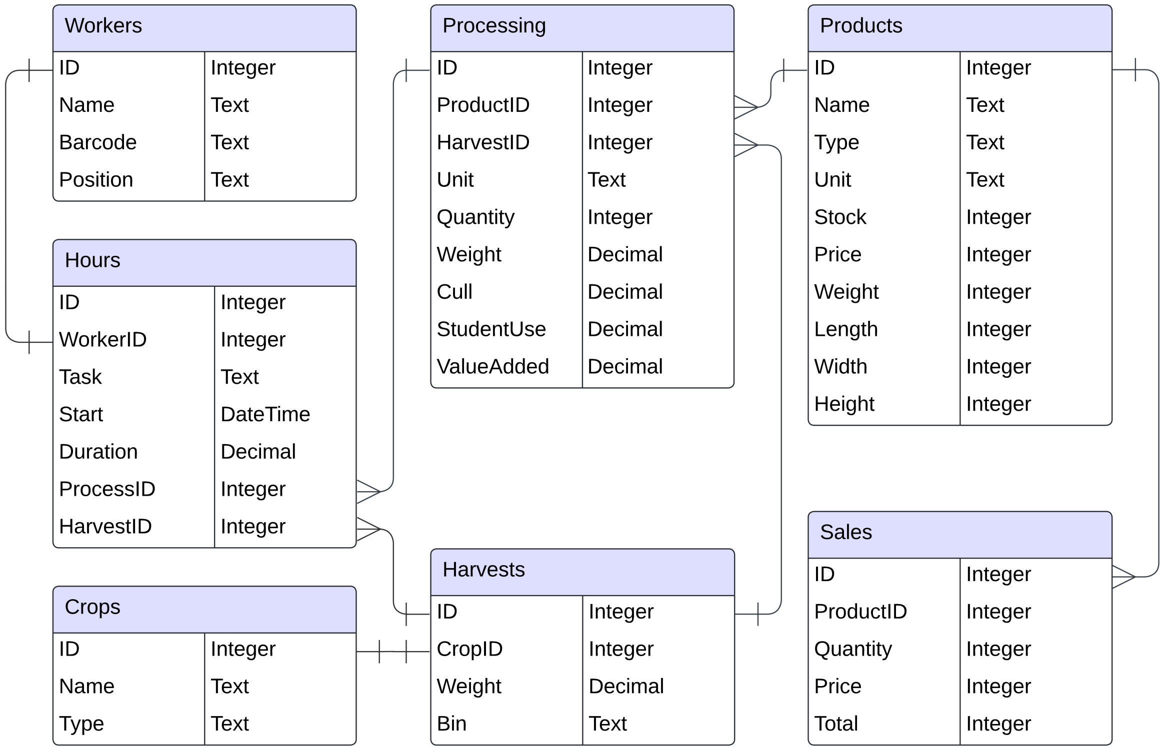

Figure 4: Diagram of the database

Power Diagram

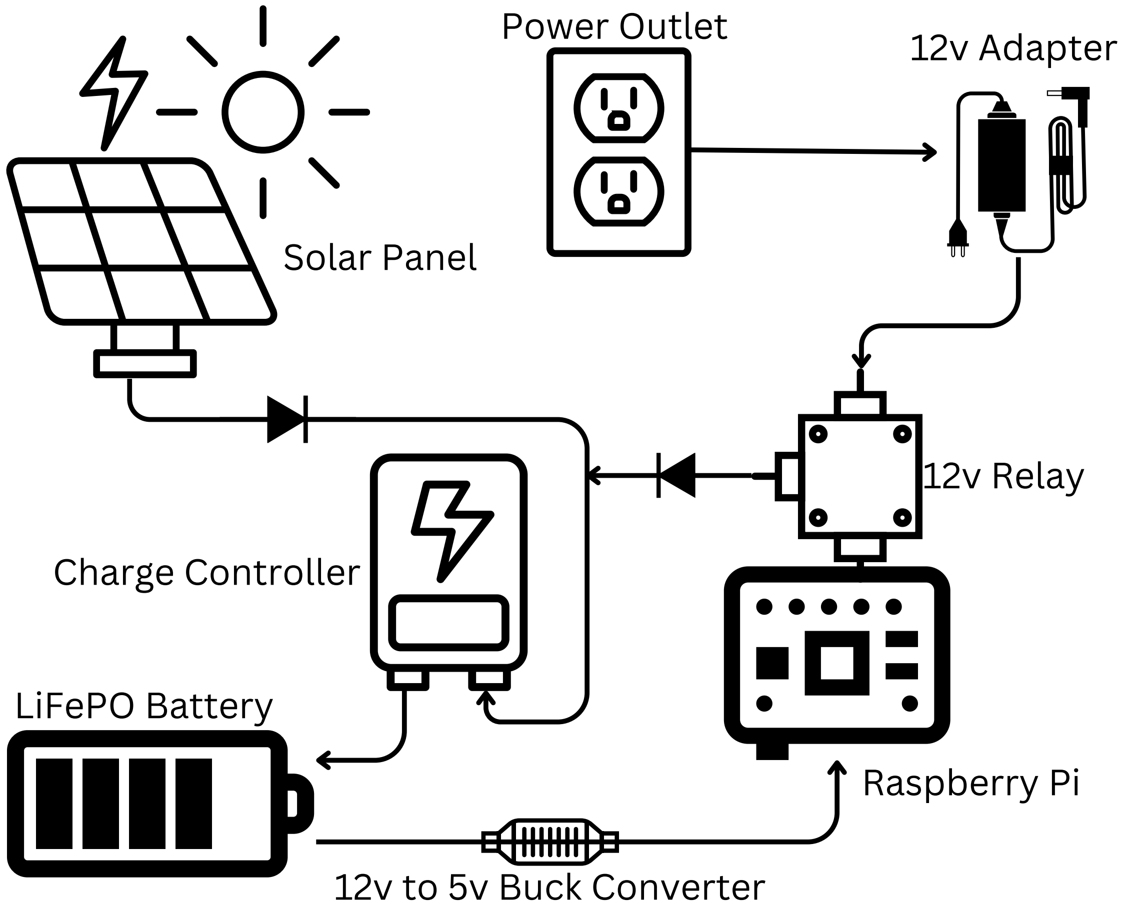

Figure 5: Diagram of the solar power system

Fall Quarter Part List

Sections listed in order of necessity.

Server Components

- Raspberry Pi 4 8gb $75
- 32GB SanDisk Ultra Micro SD Card $12.86
- Waterproof Enclosure $22.99
- USB-C Power Supply $7.99

Subtotal: $118.84

User Interface Components

- 2 Industrial Bluetooth Scanners $64.59 each
- Rugged Tablet $175.99
- Tablet Wall Mount $19.99
- Waterproof Membrane Keyboard $36.99
- 2 RS232 Adapters $9.59

Subtotal: $381.33

Wireless Components

- Bluetooth 5.1 Antenna $9.99
- WiFi AC600 Antenna $27.99
- Antenna Extenders: $8.54
- Wireless Bridge $69.99

Subtotal: $116.51

Solar Components

- 100W 12v Solar Panel $39.99
- Solar Panel Extension Cable $16.99
- 12v Solar Charge Controller $18.99
- 12v 8ah LiFePO4 Battery $24.57
- 12v to 5v DC Buck Converter $8.99
- 12v DC Power Supply $14.99
- 12v Waterproof Relay $7.99

Subtotal: $132.51

Sensor Components

- 8 ESP32 Modules $39.99
- 5 Soil Moisture Sensors $9.99
- 5 Temperature Sensors $9.99
- 4 Light Sensors $6.99
- 4 3000mAh Batteries $19.75
- 6 Channel Battery Charger $9.99

Subtotal: $96.70

Hardware Overview

Edge Server

The heart of the farm information system is a Raspberry Pi, using an SD card for system storage. It's located in the wash room within a waterproof enclosure.

- **Raspberry Pi 4 8GB:** 8GB of ram for caching a robust assortment of data for rapid dissemination and manipulation. By using the Raspian OS it will be able to read data from multiple barcode scanners, scales, and other inputs; maintain an isolated wifi network and DNS service; host database, firewall, and web server systems; and facilitate IoT systems.
- **32GB SanDisk Ultra Micro SD Card:** Simple system storage media that can easily be flashed and replaced at minimal cost. The 'ultra' speeds should keep boot and restart times to a minimum.
- **Waterproof Enclosure:** An IP67 enclose is a necessity in the wet working environment of the wash room. This case has room for modules and expansion.
- **USB-C Power Supply:** Simple power supply for testing and development, or any other time the server isn't running on solar power.

User Interface

Users will interact with the information system through barcode scanners, scales, tablets, and web browsers.

- **Industrial Bluetooth Scanners:** Industrial barcode scanners which are dustproof, waterproof, battery powered, and communicate over bluetooth. The Raspberry Pi is able to interpret each scanner as a separate input, allowing for multiple simultaneous workflows.
- **Rugged Tablet:** A waterproof wall mounted tablet to display current information, usable with a stylus even with gloves or dirty hands. Includes power supply for recharging.
- **Tablet Wall Mount:** By mounting the tablet on the wall it can be visible to multiple workers at the same time.
- **Waterproof Membrane Keyboard:** Bluetooth wireless waterproof QWERTY keyboard for use with the tablet.
- **RS232 Adapter:** This adapter allows the Raspberry Pi to read the output from the scale, relieving the need to hand-record weights.

Wireless

Wireless communication is essential for the cordless operation of sensors and input devices with the server, as well as the bridge from the farm hub to the wash station.

- **Wireless Bridge:** The wireless bridge provides a secure end-to-end connection over long distances; it connects an ethernet port at the farm hub to an ethernet port in the wash station, as if they were directly plugged in to one another.
- **Bluetooth 5.1 Antenna:** The Raspberry Pi has a default bluetooth range of about three feet, with this antenna we can extend the range over 100 feet.
- **WiFi AC600 Antenna:** This wireless antenna vastly extends the wifi range of the Raspberry Pi, allowing it to oversee a mesh network connecting sensors and tablets in nearby fields.
- **Antenna Extenders:** These cables allow an antenna to be positioned a short distance away from the receiver. Both the bluetooth and wifi antennas need to be positioned on the outside of the edge server enclosure for maximum effect.

Solar

A modest solar panel connected to a charge controller and battery is sufficient to reliably power the information system. Due to the low power consumption of the Raspberry Pi, it is a strong candidate for solar power sources.

- **100W 12v Solar Panel:** With an average daily yield of 400 watts, a single solar panel is able to provide more than the 288 watts required to power a Raspberry Pi for 24 hours.
- **Solar Panel Extension Cable:** These cables allow the solar panel to be placed at a distance from the battery and charge controller.
- **12v Solar Charge Controller:** A charge controller is necessary to put the power from the solar panel into a battery. It can also be used to charge the battery with 12v current from a wall adapter.
- **8ah LiFePO4 Battery:** Durable, compact and sealed battery storage with plenty of capacity for connected systems.
- **12v to 5v DC Buck Converter:** This device converts the 12v power from the battery and solar panel into 5v power required by the Raspberry Pi.
- **12v DC Power Supply:** Simple power supply to charge the battery in case solar power ever falls short.
- **12v Waterproof Relay:** A switch to toggle the 12v power supply, controlled by the Raspberry Pi.

Sensors

An array of sensors monitoring growing conditions in multiple areas can be connected into a mesh network and leveraged to collect invaluable data.

- **ESP32 Modules:** Low power wifi-connected micro controllers compatible with a variety of sensors and powered by a small battery.
- **Soil Moisture Sensors:** Ground probes to detect the humidity level in soil.
- **Temperature Sensors:** Durable waterproof temperature probes.
- **Light Sensors:** Basic light intensity sensors.
- **3000mAh Batteries:** Rechargable batteries for ESP32 capable of powering the devices for several days of operation.
- **6 Channel Battery Charger:** Battery charging unit capable of recharging half a dozen batteries at a time for the ESP32s.