Introduction

Efficient resource management in agriculture and landscaping has become critically important due to mounting environmental pressures. Two of the most pressing issues are the unnecessary overuse of water for irrigation—leading to water scarcity and waste—and the excessive application of fertilizers and chemicals, which infiltrate the soil and contaminate groundwater.

This project addresses these challenges by leveraging real-time, sensor-driven monitoring to optimize irrigation precisely when and where it's needed. By integrating an ESP32 microcontroller with a VL53L8CX Time-of-Flight (ToF) sensor, the system can detect the presence and position of plants or objects in a monitored area. Coupled with instant wireless data transmission and automated control of watering systems, the setup enables the following environmental benefits:

- **Water Conservation:** Irrigation is triggered only when the sensor detects plant presence and proximity, reducing unnecessary watering and helping to preserve scarce water resources.
- **Targeted Fertilizer Application:** By knowing exactly where and when plants are present, the system can help guide precise application of fertilizers and reduce runoff—limiting the amount of chemicals infiltrating natural soil and groundwater.
- **Reduced Environmental Footprint:** Intelligent control systems such as this not only save resources but also help reduce the carbon footprint and ecological impacts associated with traditional, less-efficient agricultural practices.

This project demonstrates how low-cost, network-connected sensors and automation hardware can contribute to sustainable practices in agriculture, urban gardening, or landscape management. The following report details both the hardware and software necessary to build the system, so others can replicate and further adapt it to address environmental needs in their own communities.

Materials and Methods

Materials

- ESP32 Development Board: Primary controller running FreeRTOS.
- VL53L8CX ToF Sensor Module: Delivers 8×8 grid distance measurements for object/plant detection.
- Push-Button Switch: User input, event annotation.
- LED, relay, or actuator (connected to GPIO7): Controls irrigation.
- Wiring/Breadboard or PCB: For sensor, switch, and actuator connections.
- Client computer/device: Receives sensor data via TCP.
- Power Supply: For ESP32 and peripherals.
- Wi-Fi Network: For ESP32 to connect and transmit data.

Pin Assignments

Function	ESP32 GPIO	Notes
I2C SCL	9	ToF sensor
I2C SDA	8	ToF sensor
ToF sensor reset	5	XSHUT line
Output (Actuator)	7	Controls valve/LED/relay
Input (positioning marks reader)	4	With internal pull-up enabled

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