Design and Development of an IoT-Based Oil Collecting System

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ABSTRACT

Improper disposal of waste cooking oil (WCO) remains a persistent environmental problem, with domestic discards contaminating waterways and wasting a recoverable resource. This study presents the design and evaluation of an IoT-monitored oil collecting system that marries automated weighing with real-time data reporting to incentivize WCO recovery. The prototype integrates a single-point load sensor with an HX711 amplifier and a NodeMCU ESP32 controller. Measured mass is converted on device to a monetary value, displayed on a 16×2 LCD, and streamed to a centralized dashboard via the Blynk IoT platform for counter-side oversight. Development followed a staged workflow- simulation, PCB layout/fabrication, and full hardware integration; prior to functional testing. Under initial (no-load) conditions, the LCD shows zero and a red LED indicates readiness; upon loading, the system computes the corresponding cash amount, updates the display, and posts values to Blynk. A green LED confirms successful logging, and the counter can issue a reset from the interface. Testing showed the prototype meets its objectives: it reliably weighs WCO, performs on-device weight-to-currency conversion, and enables remote monitoring of per-user accumulations. Beyond technical performance, the system operationalizes behavioural incentives (cash rewards) to motivate household participation, supporting sustainability aims such as protecting water systems and reducing reliance on virgin resources. Overall, the results indicate that a low-cost IoT architecture can link environmental protection with economic benefit in community recycling programs, providing a practical pathway to scale responsible WCO management.

Keywords: Waste Cooking Oil, IoT, Smart Waste Management, Real-Time Monitoring, Behavioural Incentives

INTRODUCTION

Waste cooking oil (WCO) is a near-universal by-product of domestic and commercial food preparation, consisting predominantly of triglycerides with smaller fractions of mono-/diglycerides and free fatty acids. Far from being mere waste, WCO is a versatile secondary resource for chemicals and materials (Mannu et al., 2023) and a practical feedstock for biodiesel and other bioproducts, thereby reducing dependence on virgin fossil inputs within a circular-economy paradigm (Ahmadbeigi et al., 2024; De Feo et al., 2023; Kumar et al., 2025; Lopresto, 2025). Nevertheless, in many contexts WCO is still discharged into sinks, drains, or landfills, driving water contamination, sewer blockages, and increased treatment costs; London's "fatberg" events illustrate the systemic risks of improper disposal (Omidvar et al., 2023).

Malaysia exhibits similar behavioural and infrastructural challenges. Household survey evidence from Petaling indicates low participation in WCO recycling and prevalent disposal through sinks and drains, revealing substantial untapped recovery potential and persistent environmental externalities (Álvarez et al., 2025). Figure 1 summarizes typical disposal routes, while Figure 2 depicts the local recycling status, both underscoring the need for practical interventions at the community level.

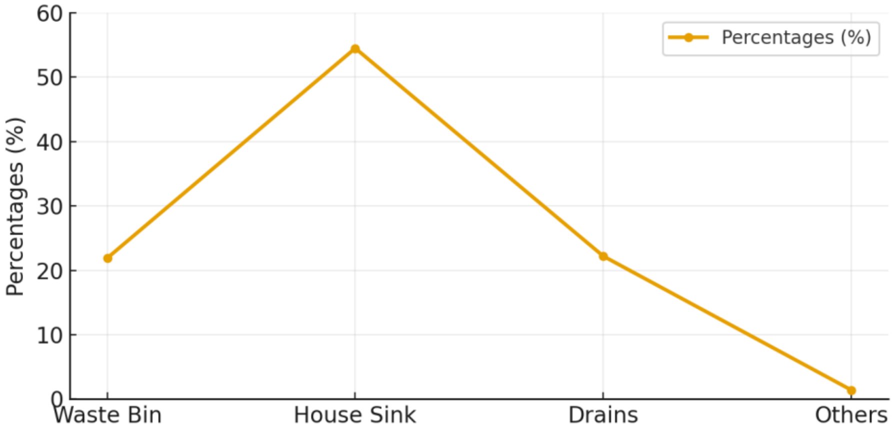

Figure 1: Reported Household WCO Disposal Means (Álvarez et al., 2025)

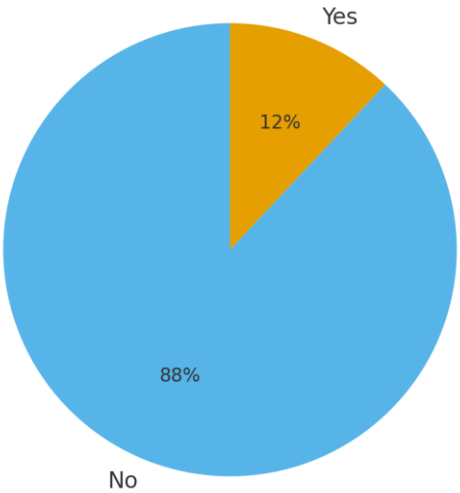

Figure 2: Household WCO Recycling Status (Álvarez et al., 2025)

Although industry initiatives such as station-based buy-back programmes are expanding (PETRONAS lists numerous collection points nationwide), coverage, transparency, and user engagement remain uneven (Mannu et al., 2025). Internationally, research on optimising WCO collection logistics, facility siting, and system design continues to grow, highlighting the need for approaches that integrate technology, operations, and user incentives (De Feo et al., 2023; Fernandez et al., 2022; Lopresto, 2025).

At present, many collection points rely on conventional industrial scales to record weight; a minority use price-conversion displays that still require manual record-keeping and offer limited data visibility for operators and users (Ahmadbeigi et al., 2024; Lopresto, 2025). Such arrangements provide little real-time oversight and weak behavioural cues. By contrast, low-cost Internet-of-Things (IoT) architectures can enable automated sensing, immediate valuation, and cloud connectivity; capabilities well suited to coupling environmental outcomes (oil diverted from wastewater) with economic signals (cash rewards) that reinforce pro-recycling behaviour (Ahmadbeigi et al., 2024; Beghetto, 2025; Kumar et al., 2025).

This study addresses that gap by developing and evaluating an IoT-monitored oil-collecting system. The prototype integrates a single-point load cell with an HX711 amplifier for mass measurement, a NodeMCU ESP32 for on-device processing and Wi-Fi connectivity, and a 16×2 LCD for local feedback; components selected for accuracy, cost, and ease of deployment in community settings (Fapohunda & Gbadegesin, 2022; Shi et al., 2024; Velmurugan et al., 2022). A preset conversion rate translates measured mass to monetary value, while a cloud dashboard (Blynk) enables counter-side, real-time monitoring of user-level accumulations to improve transparency and trust. The electronics are implemented on a custom printed-circuit board (PCB) to enhance robustness and reproducibility for scaling and field use (Cadence, 2019).

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The work pursues three objectives: (i) design a prototype that accurately weighs collected WCO; (ii) implement on-device conversion of weight to cash with local display; and (iii) enable remote, real-time monitoring via an IoT platform. In doing so, it operationalises a socio-technical approach that links environmental protection with economic benefit, with potential to increase participation in WCO recovery and support sustainability targets in water quality, waste reduction, and renewable fuel production (Ahmadbeigi et al., 2024; De Feo et al., 2023; Kumar et al., 2025; Mannu et al., 2023; Mannu et al, 2025). The remainder of the paper details the system architecture and implementation, reports functional evaluation results, and discusses implications for community-based recycling programmes and policy instruments that leverage modest financial incentives to shift household waste practices.

METHODOLOGY

Project Overview and Workflow

This study employed a staged, iterative approach to progress from concept to a fully functional prototype of the IoT-Monitored Oil Collecting System. Figure 3 shows the block diagram of the research workflow; beginning with requirements specification and simulation, followed by bench validation and PCB realization, and culminating in the final validated prototype.

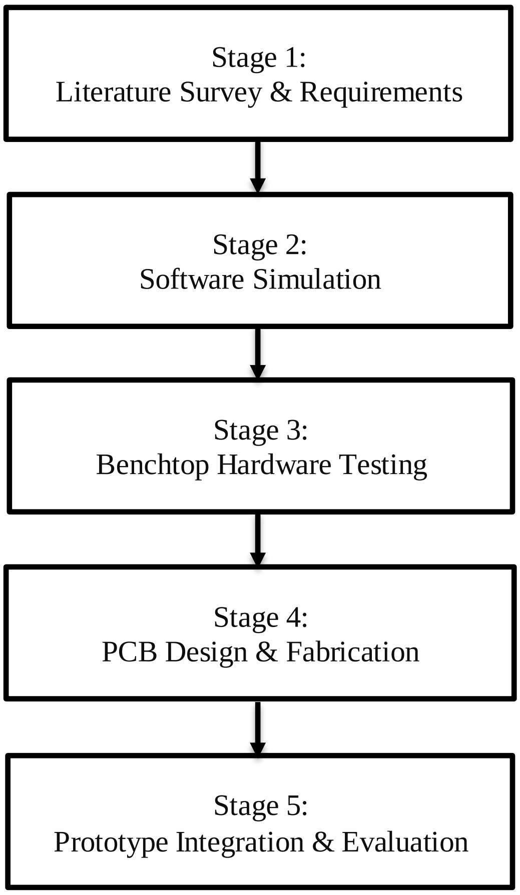

Figure 3: Project Methodology for The IoT-Monitored Oil Collecting System

i) Stage 1 - Literature Survey & Requirements: Relevant work on waste-cooking-oil (WCO) recovery, user incentives, and low-cost sensing/IoT solutions was reviewed to define the system's functional and performance requirements. The agreed specification included: weighing range and resolution, on-device weight-to-currency conversion, local display, cloud connectivity for remote monitoring, and a simple user interface. Scope and success criteria were confirmed through supervisor consultations.
ii) Stage 2 - Software Simulation: A complete schematic was constructed in Proteus 8 Professional, and baseline firmware was written in the Arduino IDE. A preliminary Blynk template (datastreams and authentication) was set up to validate the data model early. The simulation served to verify logic, signal

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flow, and basic state transitions (idle → measure → post → reset) before any hardware was procured. Only upon a clean compile and correct simulated behavior did the project advance.

iii) Stage 3 - Benchtop Hardware Testing: Validated components were assembled on a breadboard: a single-point load cell interfaced via HX711 to an ESP32 (NodeMCU), a 16×2 LCD over I²C, and status LEDs with current-limiting resistors. Tests focused on (i) stable ADC readings and linear response under known masses, (ii) reliable LCD/I²C communication, and (iii) Wi-Fi connectivity and Blynk posting. Any anomalies prompted targeted troubleshooting of code, wiring, or component choice until the bench prototype met the simulated behavior.

iv) Stage 4 - PCB Design & Fabrication: The proven breadboard circuit was captured and laid out in EasyEDA and passed electrical-rule and design-rule checks. A single-sided photoresist process (UV exposure, develop, etch, strip) produced the board, which was then drilled and assembled. Continuity checks and staged power-up (5 V rail → 3.3 V rail → ESP32 boot → HX711 enumeration → LCD/I²C → Wi-Fi) verified build integrity, with rework performed as required.

v) Stage 5 - Prototype Integration & Functional Evaluation: Electronics were mounted in a rigid enclosure and coupled to the weighing platform per load-cell mounting guidance to minimize vibration and maintain linearity. Calibration applied a two-step procedure (tare and span using known masses) with coefficients stored in non-volatile memory. Functional evaluation exercised representative user flows: tare, weigh, automatic currency conversion at a preset rate, local display update, cloud posting to Blynk, and remote reset by the counter. Acceptance focused on accurate and repeatable mass readings, correct valuation/display, successful cloud updates, and clear user feedback via LEDs.

Figure 4 shows the block diagram of the proposed IoT-Monitored Oil Collecting System, summarizing the operating flow.

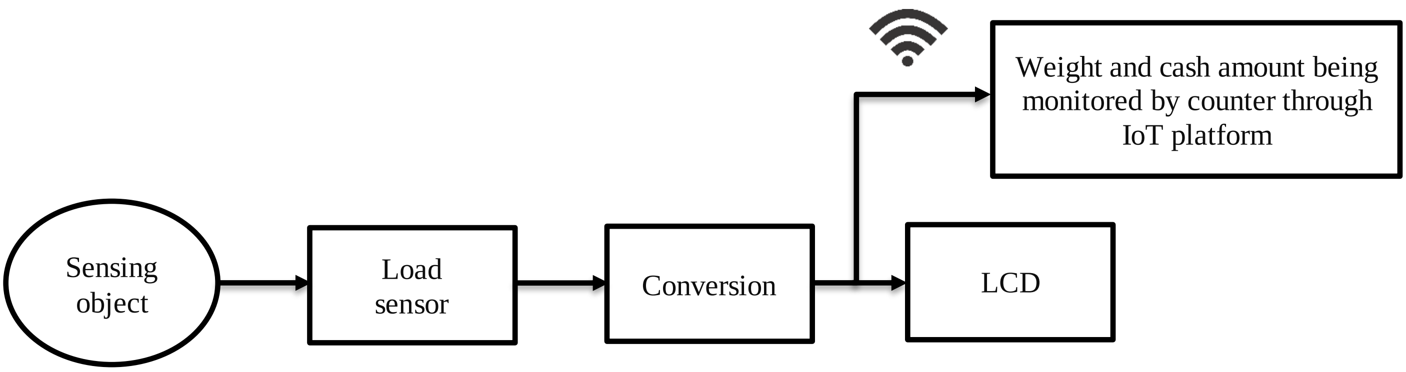

Figure 4: Block Diagram of the Proposed IoT-Monitored Oil Collecting System

The system uses a single input - the load sensor, and three local outputs: a 16×2 LCD for displaying weight and the computed cash value, a red LED indicating ready/idle status, and a green LED confirming successful data posting. In the idle state, the LCD reads zero and the red LED is on. When a container is placed on the platform, the load sensor signal is acquired and processed to determine mass; the firmware then converts mass to a cash amount using a preset rate and updates the LCD. The same data are transmitted to the Blynk IoT dashboard for remote monitoring. Upon successful upload, the green LED turns on, signaling that the load may be removed.

Software

(A) Proteus 8 Professional Software Application

Proteus 8 Professional was used to design the project's schematic and to perform circuit-level simulations prior to hardware assembly. Its workspace provides a component library, schematic editor, and instrumentation for validating logic, signal flow, and interconnections. In this study, Proteus served primarily for software simulation of the complete circuit (see Figure 5), enabling early debugging and verification before moving to benchtop testing and PCB design.

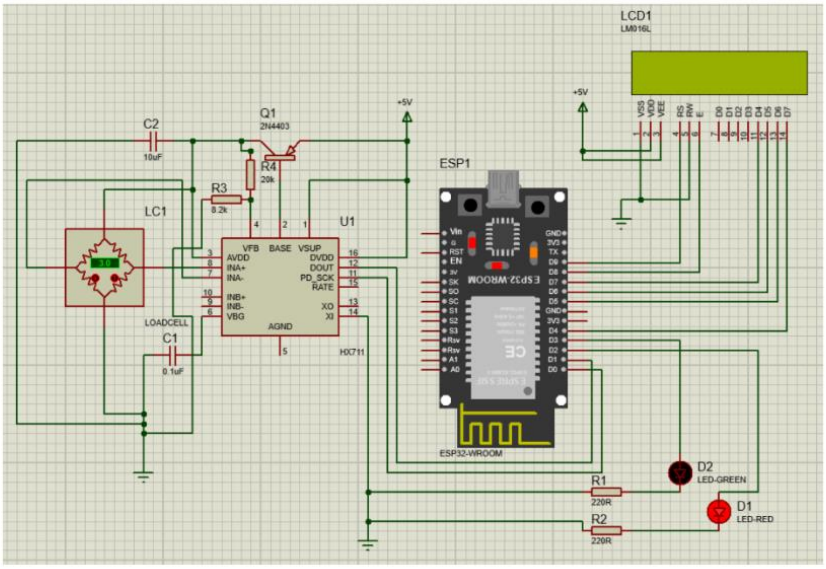

Figure 5: Main Workspace of Proteus 8 Professional with the Project Schematic for Simulation

(B) Arduino Integrated Development Environment (IDE)

Firmware was developed and deployed using the Arduino IDE, which governs the ESP32 microcontroller and thereby the operation of the entire system. The IDE provides a “sketch” editor, compiler, and uploader for C/C++ code; in our case, the firmware implements HX711 sensor acquisition, calibration coefficients, digital filtering, LCD/I²C routines, Wi-Fi connectivity, Blynk communication, and a simple state machine for user feedback (LEDs/LCD). Draft code was first verified to catch syntax and linkage errors, then uploaded to the ESP32 for bench testing and iteration.

(C) EasyEDA (Web)

EasyEDA was used primarily for schematic capture and PCB layout. The editor provides a web-based workspace with extensive part libraries, user-contributed components, and editable footprints. Figure 6 shows the EasyEDA workspace with the project schematic, and Figure 7 shows the finalized PCB layout for the IoT-Monitored Oil Collecting System. The workflow began by drafting the complete schematic, selecting or customizing footprints, and then converting the design to a PCB. Autorouting was applied as a starting point and subsequently refined by manual edits to trace widths, clearances, copper pours, and drill sizes to suit component current demands and connector geometry. Design-rule checks (DRC) were performed before exporting fabrication files.

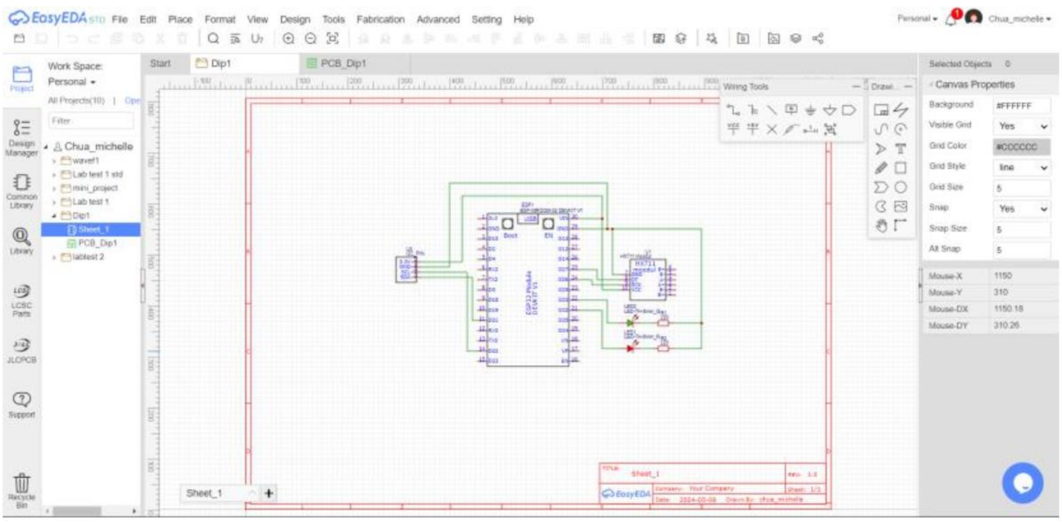

Figure 6: EasyEDA Web Workspace Showing the Project Schematic for the IoT-Monitored Oil Collecting System

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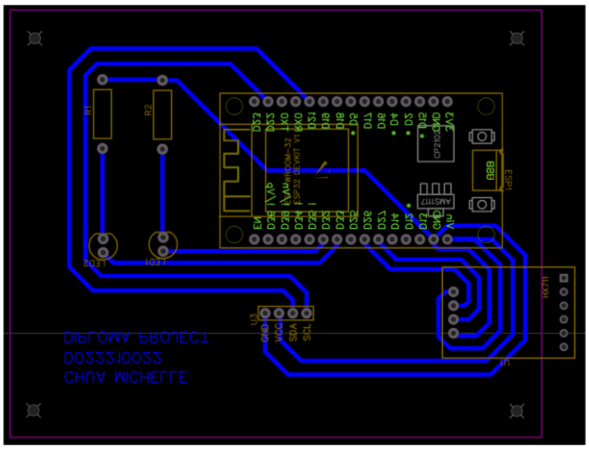

Figure 7: Final PCB Layout of the IoT-Monitored Oil Collecting System Designed in EasyEDA

(D) Blynk Cloud (Web)

For the IoT layer, the project uses Blynk Cloud (web) to provision the device, define data channels, and visualize system status. After Wi-Fi configuration on the ESP32, telemetry (weight, cash value, status flags) is published to Blynk and control commands (e.g., Reset) are received from the dashboard. Figure 8 shows the web workspace used to design the project template - creating datastreams and assigning widgets, while Figure 9 shows the live device interface for the IoT-Monitored Oil Collecting System. The dashboard layout was customized by adding widgets (value displays, indicators, and a reset button) and binding them to the respective datastreams, enabling real-time monitoring and counter-side control.

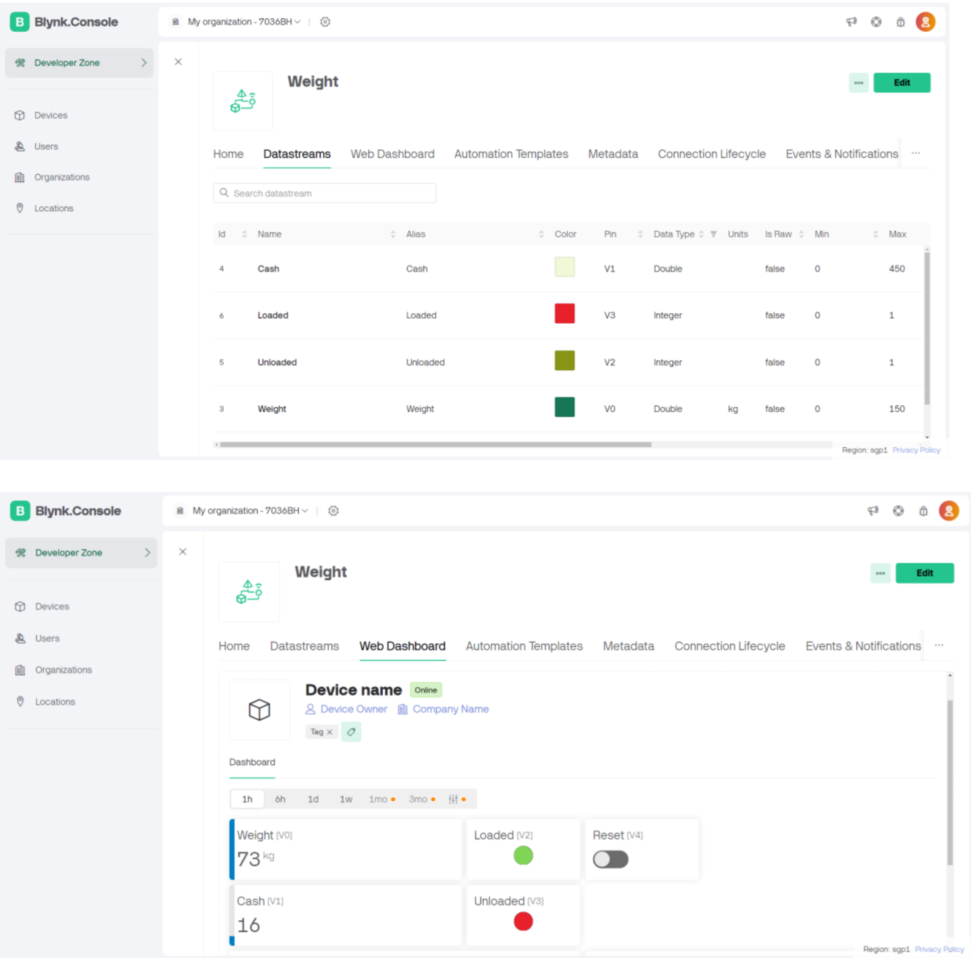

Figure 8: Blynk Cloud (Web) Workspace Showing the Project Template: (a) Configured Datastreams, and (b) Widgets

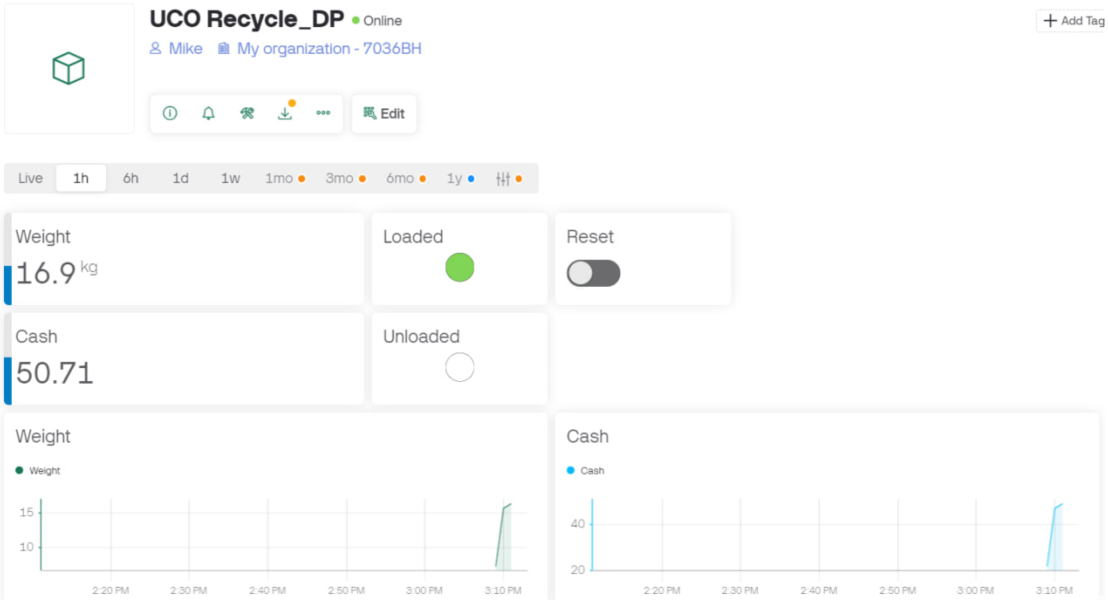

Figure 9: Live Blynk Device Dashboard for The IoT-Monitored Oil Collecting System (Value Displays, Status Indicators, and Reset Control)

(E) Blynk Cloud Mobile Application

The project also uses the Blynk Cloud mobile app as a companion to the web dashboard for real-time monitoring and control. After device provisioning, the same template and datastreams are available on mobile, enabling users to view weight and cash values, check status indicators, and issue commands (e.g., Reset) from a phone. Figure 10 shows the mobile dashboard interface for the IoT-Monitored Oil Collecting System, providing equivalent functionality to the web version with improved portability.

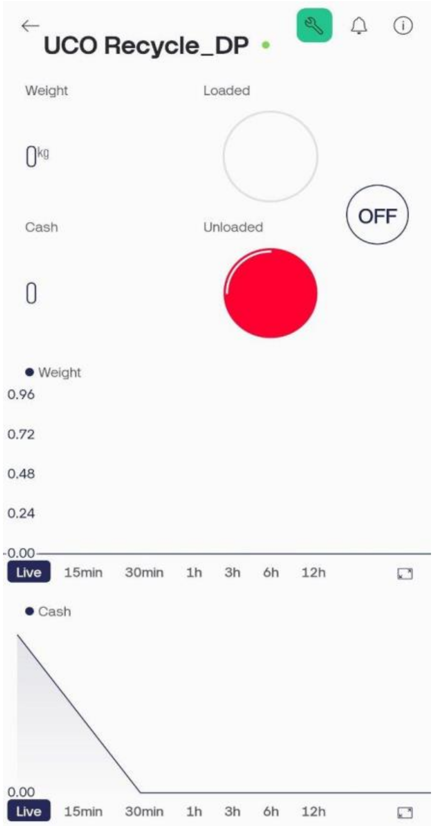

Figure 10: Blynk Cloud Mobile Dashboard for the IoT-Monitored Oil Collecting System, Showing Live Weight and Cash Values, Status Indicators, and the Reset Control

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Hardware

(A) NodeMCU ESP32

The project uses the NodeMCU ESP32 as the main controller (see Figure 11). The ESP32 integrates a dual-core MCU with on-board Wi-Fi, eliminating the need for an external wireless module and making it well suited for IoT applications. The board can be powered at 5 V (recommended here to ensure reliable LCD operation) while its logic level operates at 3.3 V. It provides ~30 I/O pins, including dedicated SDA/SCL lines for the I²C backpack of the 16×2 LCD. Firmware is uploaded via a micro-USB connection to a host computer (see Figure 12), which also supplies power during development and testing.

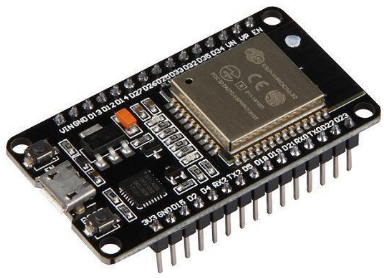


Figure 11: Nodemcu ESP32 Development Board Used as the Main Controller

Figure 12: Micro-USB Cable for Firmware Upload and Bench Power During Development

(B) Single-Point Load Sensor

The weighing element is a single-point load cell rated to 40 kg (see Figure 13; key specifications in Figure 14). A single-point type was selected for its high accuracy and stability in platform-scale applications and its tolerance to off-center loading. The sensor operates on the strain-gauge Wheatstone-bridge principle: elastic deformation under load produces a small differential voltage proportional to applied force. Because this output is in the millivolt range and cannot be read directly by the microcontroller, the bridge signal is conditioned by an HX711 instrumentation amplifier/24-bit ADC prior to digitization. The load cell is calibrated in firmware (tare and span using known masses), with coefficients stored for subsequent measurements.

Figure 13: Single-Point Load Cell (40 Kg Capacity) Used as the Weighing Transducer

Specification

Approved according to:	CE RoHS NTEP Ex OIML
Capacity (kg):	40 kg
IP class:	IP66
Load cell type:	Single point (off center)
Material:	Aluminium

Figure 14: Key Specifications of the Selected Single-Point Load Cell (Rated Capacity, Accuracy, and Electrical Characteristics)

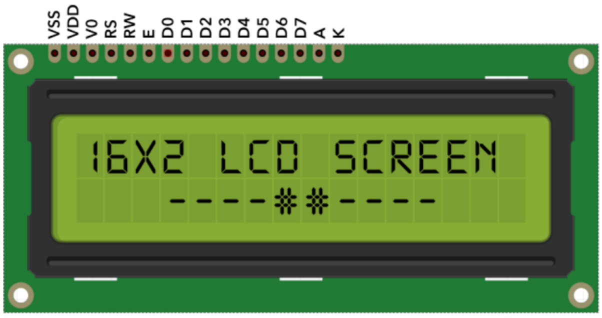
(C) HX711 Load Cell Amplifier

Because the load cell produces a millivolt-level differential signal, front-end conditioning is required before digitization. The project uses the HX711 load-cell amplifier/ADC module (see Figure 15), which integrates an instrumentation amplifier and high-resolution converter on a small PCB. The HX711 interfaces directly with the single-point load cell, provides stable gain for bridge outputs, and delivers digitized readings to the ESP32 via a simple two-wire serial interface. In the system, the HX711 is placed between the load cell and the microcontroller, enabling accurate, low-noise measurement of applied mass for subsequent calibration, valuation, and display.

Figure 15: HX711 Load-Cell Amplifier/24-Bit ADC Module Used to Condition and Digitize the Load-Cell Signal Before the ESP32

(D) 16×2 LCD with I²C Interface

A 16×2 character LCD provides local feedback by displaying the measured weight and the computed cash value (see Figure 16). To minimize GPIO usage on the ESP32, the display is fitted with an I²C backpack, reducing the required connections from ~6 parallel lines to four pins: VCC, GND, SDA, and SCL (see Figure 17). The LCD communicates with the ESP32 over the I²C bus using the dedicated SDA/SCL lines, simplifying wiring and preserving pins for other peripherals. Figure 18 shows the assembled 16×2 LCD with the I²C module attached as used in the prototype.



No	Symbol	Function
1	VSS	Ground
2	VDD	5V +
3	V0	Contrast
4	RS	Register
5	RW	Read/Write
6	E	Enable
7	D0	Data bus
8	D1	Data bus
9	D2	Data bus
10	D3	Data bus
11	D4	Data bus
12	D5	Data bus
13	D6	Data bus
14	D7	Data bus
15	A	Anode (5V+)
16	K	Cathode (GND)

Figure 16: 16×2 Character LCD Used for Local Display of Weight and Cash Value

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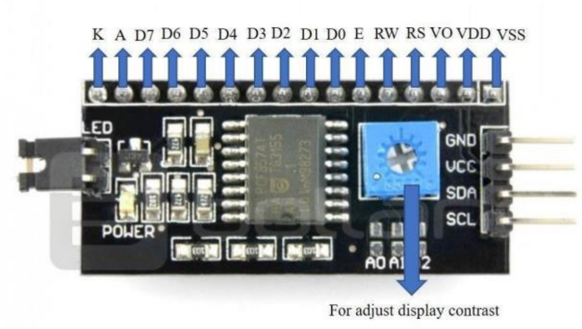

Figure 17: I²C Backpack Module (SDA/SCL Interface) Attached to The LCD to Reduce GPIO Usage

Figure 18: Assembled 16×2 LCD with I²C Interface as Implemented in the Prototype

(E) Light-Emitting Diodes (LEDs)

Two status LEDs - red and green, provide local user feedback (see Figure 19). The red LED indicates the idle/ready state when no load is present (LCD reads zero). After the system measures the load, converts weight to cash, and successfully posts the data to Blynk, the green LED turns on to signal that the container may be removed. Each LED is connected in series with a 220 Ω fixed resistor to limit current and prevent overdrive.

Figure 19: Red and Green Status LEDs (With 220 Ω Series Resistors) Indicating the Ready/Idle State and Successful Data Posting, Respectively

(F) Fixed Resistors

Two 220 Ω fixed resistors are used in series with the red and green LEDs to limit current and prevent overdrive (see Figure 20). The resistor value follows the standard color code (see Figure 21): red–red–brown corresponds to $22 \times 10^1 = 220\ \Omega$, with the tolerance band indicating the specified accuracy. These resistors ensure reliable LED operation across normal supply variations.

Figure 20: 220 Ω Fixed Resistor Used for LED Current Limiting in The Prototype

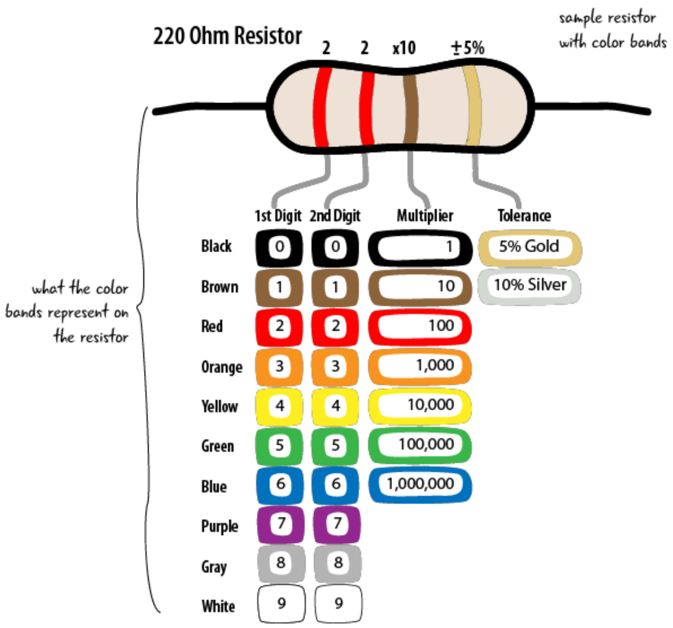

Figure 21: Color Code for A 220 Ω Resistor (Red–Red–Brown; Tolerance Band Indicates Accuracy)

Printed Circuit Board (PCB) Fabrication

PCB fabrication converts the finalized schematic and layout into a physical board suitable for reliable system integration. For this project, the design was exported from the CAD tool and printed onto a transparent film to create the artwork (Figure 22). The board was then processed using standard photoresist techniques - UV exposure through the artwork, chemical development to reveal the copper pattern, controlled etching to remove unwanted copper, and resist stripping - followed by drilling and cleaning. Continuity checks were performed prior to assembly to verify trace integrity and readiness for component soldering.

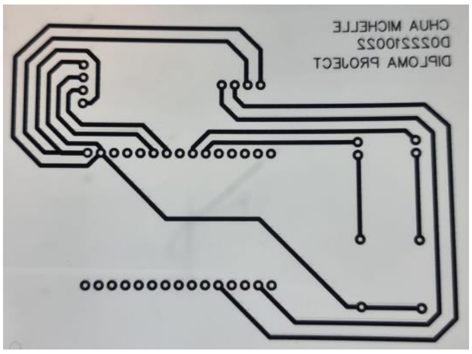

Figure 22: PCB Layout Printed on Transparent Sheet

Prototype Development

The prototype of the IoT-Monitored Oil Collecting System was assembled following PCB validation and subsystem tests. The electronics were mounted in a rigid mounting-board enclosure selected for stiffness and vibration damping, which is important for stable load-cell readings. The weighing platform was mechanically coupled to the single-point load cell according to the manufacturer's orientation to maintain linearity and repeatability. Figure 23 presents the overall design concept.

In operation, a container placed on the platform applies force to the load cell; the HX711 front end and ESP32 firmware compute mass, convert it to a cash value using a preset rate, and display both on the 16×2 LCD. Telemetry is sent to the Blynk dashboard for counter-side monitoring, and a Reset command can be issued remotely after reward collection. This integrated build demonstrates the complete user flow from weighing to valuation and cloud logging.

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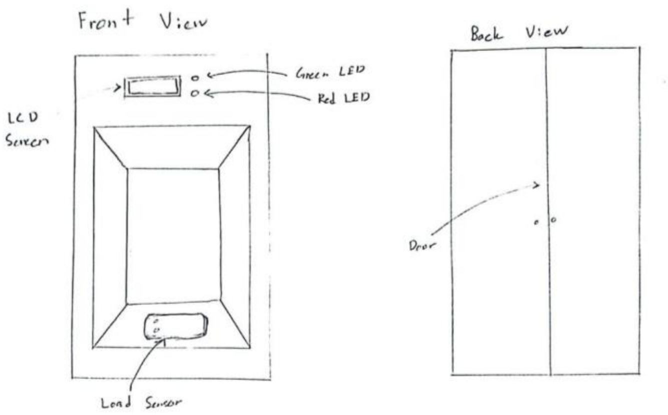

Figure 23: Design Concept of the IoT-Monitored Oil Collecting System Prototype, Showing the Enclosure, Load-Cell Platform, and Control-Electronics Layout

RESULTS AND DISCUSSION

This section reports the outcomes of the IoT-Monitored Oil Collecting System, emphasizing the final prototype, its core functions, and issues addressed during development. It also highlights environmental relevance and potential contributions to sustainability programs.

(A) Prototype Overview

The system performs weight-to-cash conversion and enables real-time monitoring via the Blynk IoT platform. In contrast to common market offerings that provide only basic weighing or simple price display, this prototype integrates three capabilities; IoT connectivity, automated valuation, and remote monitoring - while maintaining the accuracy and stability expected of a platform scale.

Results and Functionality

Building on the overview above, this subsection documents the prototype's operation from benchtop bring-up to enclosure integration and user-facing behaviour.

(i) Breadboard Development

Figure 24 shows the benchtop prototype assembled on a breadboard to validate sensing (load cell + HX711), display (LCD/I²C), and connectivity (ESP32 ↔ Blynk) before committing to PCB fabrication. This stage was used to confirm stable readings, reliable LCD updates, and consistent cloud posting.

Figure 24: Breadboard Development of the IoT-Monitored Oil Collecting System Used for Early Validation of Sensing, Display, and Connectivity

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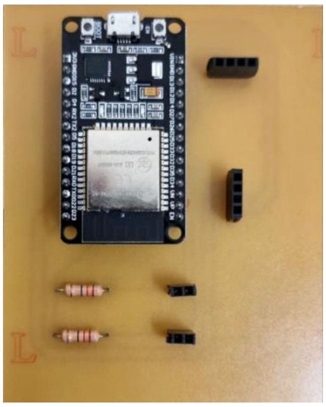
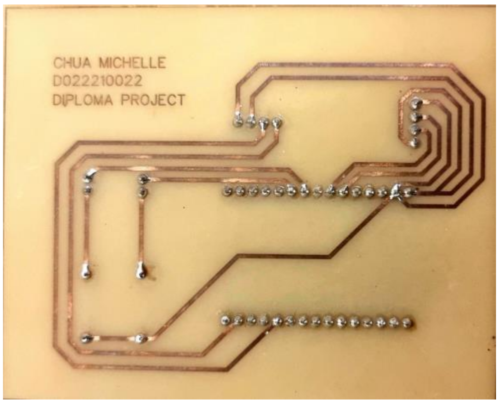
(ii) PCB Board

The fabricated PCB is presented in Figure 25 – (a) top view and (b) bottom view. Replacing the breadboard with a dedicated PCB improved robustness, signal routing integrity, and ease of deployment and maintenance.



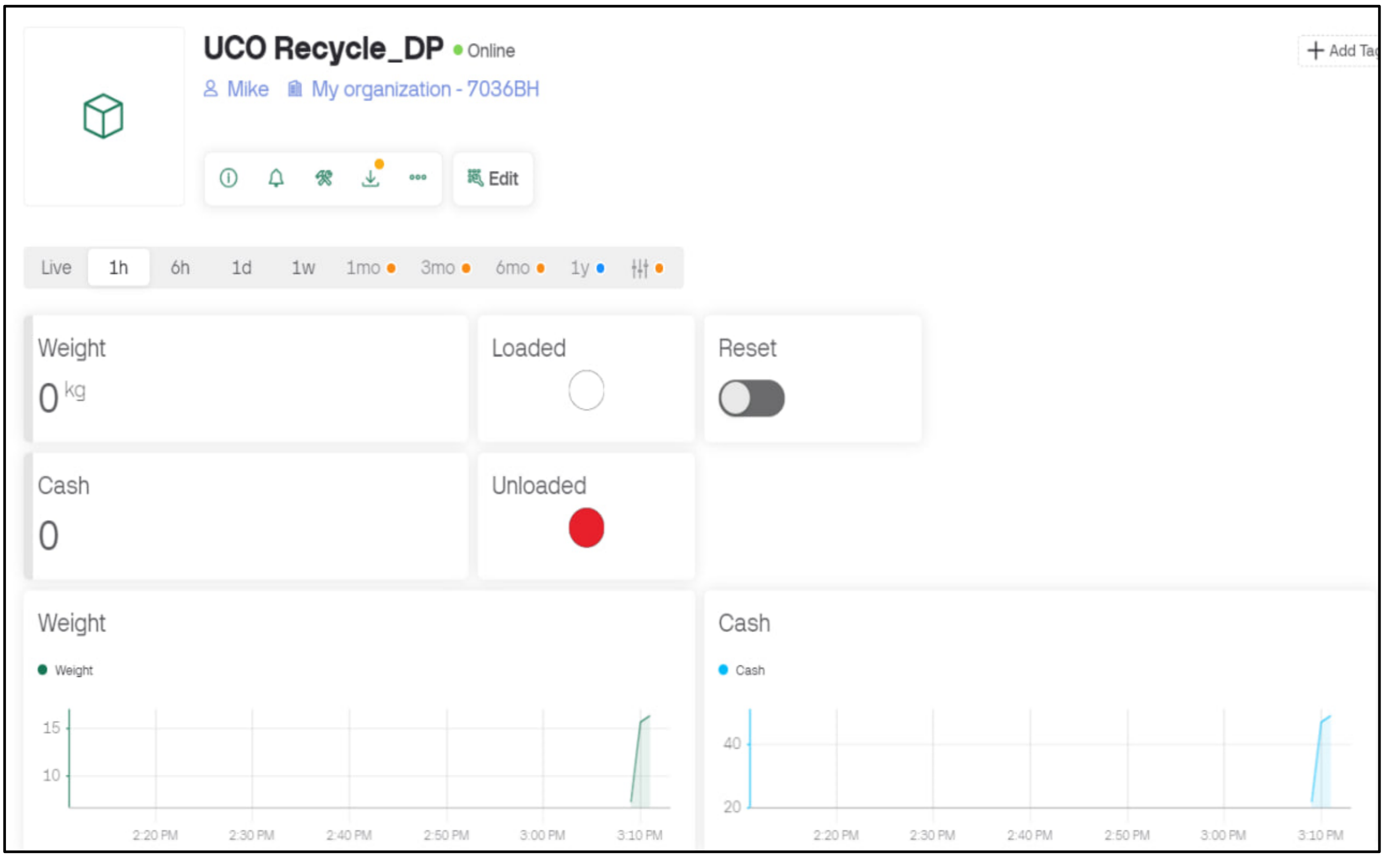


(a) (b)

Figure 25: Assembled PCB of the System: (a) Top View, and (b) Bottom View

(iii) Blynk Cloud Interfaces

Figure 26 illustrates the Blynk mobile dashboard in two normal operating states. Panel (a) depicts the initial no-load condition (weight and cash = 0; interface idle). Panel (b) shows the post-measurement condition, where the system has computed the measured weight, converted it to cash, and posted both values to the dashboard. In both states, the mobile app mirrors the device status and provides counter-side control (e.g., Reset), matching the functionality of the web interface for real-time monitoring and record management.



(a)

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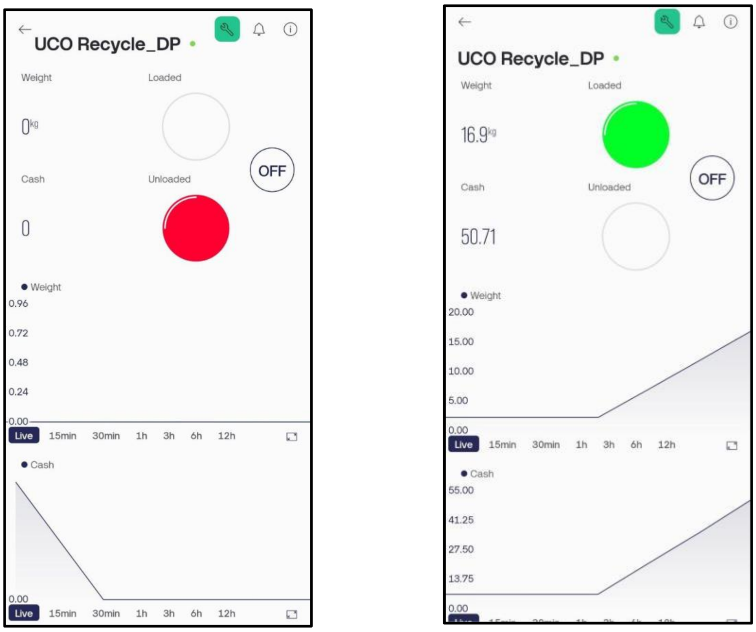
(b)

Figure 26: Blynk Mobile Dashboard for Counter-Side Monitoring: (a) No-Load (Initial) State, and (b) Values Posted After Measurement



(a) (b)

Figure 27: Blynk Mobile Dashboard States: (a) No-Load (Initial), and (b) Post-Measurement with Posted Weight and Cash

(iv) Prototype Views

Figure 28 presents the assembled unit - front, back, an overall view, and the internal wiring layout; demonstrating the mechanical coupling between the weighing platform and the load cell and the internal arrangement of the control electronics.

(a) (b) (c) (d)

Figure 28: Assembled Prototype of the IoT-Monitored Oil Collecting System: (a)Front, (b) Back, (c) Overall View; and (d) Internal Wiring Layout

(v) Functional Demonstration

Figure 29 shows the initial state: the LCD indicates zero for both weight and cash, the red LED signals ready/idle, and Blynk indicators (web and mobile) mirror the local status. Under load (Figure 30), the LCD displays the measured weight and converted cash value; after the values are posted to Blynk, the green LED confirms completion, and the counter can clear the record via the Reset control on the dashboard.

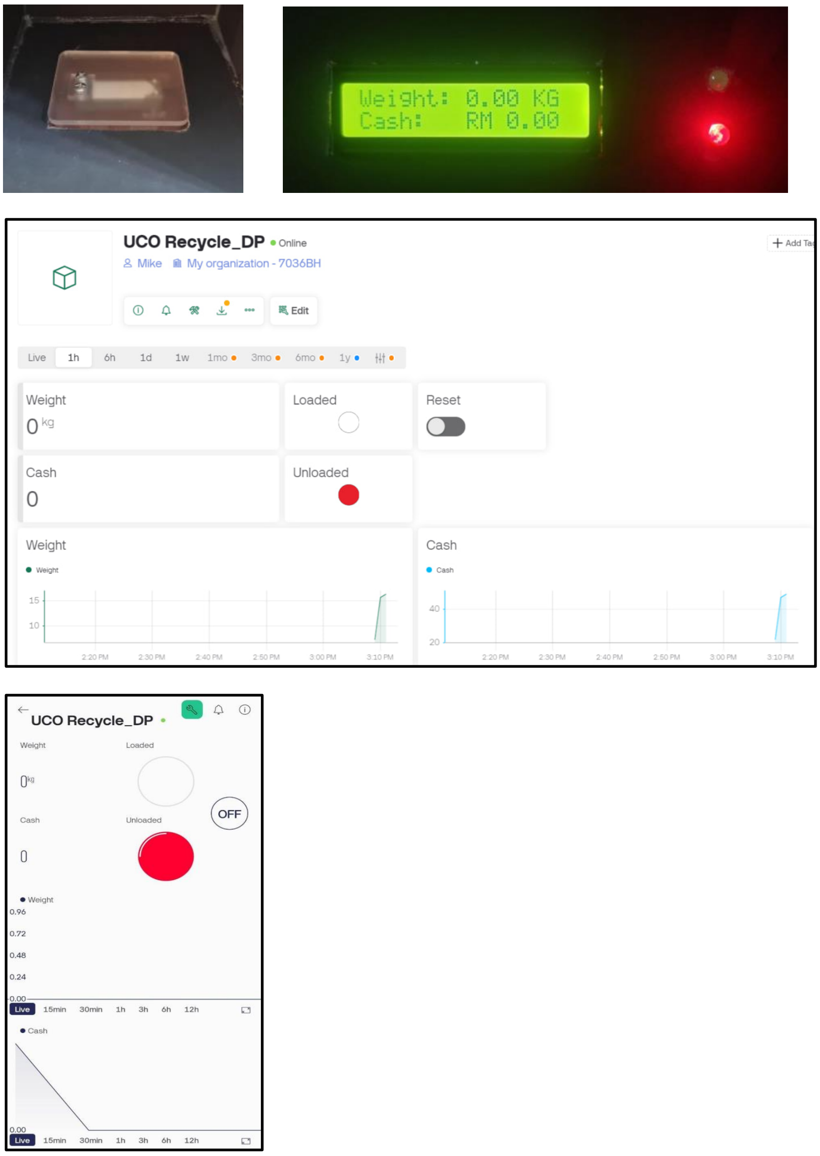


Figure 29: System Initial State: LCD Shows Zero Weight/Value, Red Led Indicates Ready/Idle, and Blynk Indicators Match Local Status

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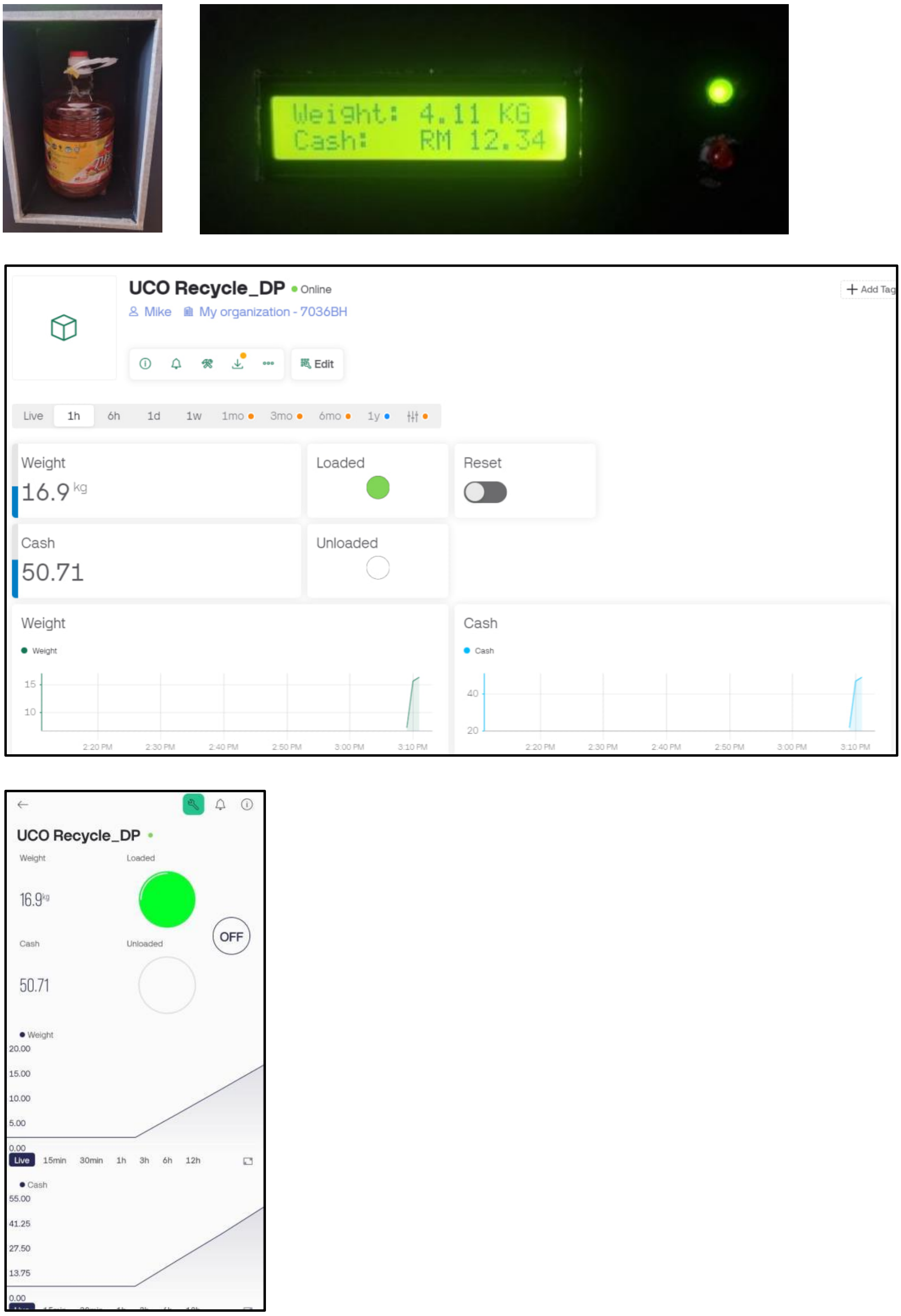

Figure 30: System Under Load: LCD Displays Measured Weight and Converted Cash Value; Data Posted to Blynk and Green Led Indicates Completion

(B) Project Reflections

Two issues encountered during development were resolved as follows:

i) Unstable Wi-Fi with external module. The initial setup (Arduino Uno R3 + ESP8266-01) did not connect reliably to Blynk. Replacing it with an ESP32 (embedded Wi-Fi) restored stable connectivity and allowed normal operation after firmware upload.

ii) Load-cell zero drift after enclosure build. The prototype initially failed to return to zero due to mechanical interference and vibration. Cutting a clearance aperture larger than the load-cell platform and elevating the platform on a wooden spacer reduced coupling to the enclosure, improving stability and restoring accurate zeroing.

CONCLUSIONS

This work produced a functional IoT-Monitored Oil Collecting System that met all stated objectives: (i) accurate weighing of used cooking oil using a single-point load cell and HX711 front end; (ii) on-device mass-to-cash conversion with results shown on a 16×2 LCD; and (iii) real-time posting to Blynk for counter-side monitoring and control. Developed through staged specification, simulation, benchtop validation, PCB realization, and integrated testing, the prototype demonstrates a practical, low-cost pathway to encourage household oil recycling. In addition to environmental benefits (reduced improper disposal and improved circularity), it offers community value by returning cash to users and improving operational transparency for collection counters. Implementation challenges - wireless instability with an external Wi-Fi module and post-integration load-cell zero drift; were addressed by adopting the ESP32 platform and refining the mechanical design, yielding stable, repeatable operation suitable for pilot deployment.

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REFERENCES

1. Ahmadbeigi, A., Mahmoudi, M., Fereidooni, L., Akbari, M., & Kasaeian, A. (2024). Biodiesel production from waste cooking oil: A review on production methods, recycling models, materials and catalysts. Journal of Thermal Engineering, 10(5), 1362-1389. https://jten.yildiz.edu.tr/storage/upload/pdfs/1725955574-en.pdf
2. Álvarez, P. M., Collado Contreras, J., & Nogales-Delgado, S. (2025). Biodiesel and Biolubricant Production from Waste Cooking Oil: Transesterification Reactor Modeling. Applied Sciences, 15(2), 575. https://doi.org/10.3390/app15020575
3. Beghetto, V. (2025). Strategies for the Transformation of Waste Cooking Oils into High-Value Products: A Critical Review. Polymers, 17(3), 368. https://doi.org/10.3390/polym17030368
4. Cadence. (2019). What is the PCB fabrication process? An introduction. Retrieved June 18, 2024, from https://resources.pcb.cadence.com/blog/2019-what-is-the-pcb-fabrication-process-an-introduction-
5. De Feo, G., Ferrara, C., Giordano, L., & Ossèo, L. S. (2023). Assessment of three recycling pathways for waste cooking oil as feedstock in the production of biodiesel, biolubricant, and biosurfactant: a multi-criteria decision analysis approach. Recycling, 8(4), 64. https://doi.org/10.3390/recycling8040064
6. Fapohunda, T., & Gbadegesin, I. (2022). Development of a programmable digital weighing scale for agro-allied industry. International Journal of Research in Agronomy, 5(2), 01–05. https://doi.org/10.33545/2618060X.2022.v5.i2a.100
7. Fernandez, C., Bernal, A., Leon, P., Gelves, O., & Malagon-Romero, D. H. (2022). Optimization of a Route for Collecting Waste Cooking Oil in Bogotá. Chemical Engineering Transactions, 91, 625-630. https://www.cetjournal.it/cet/22/91/105.pdf
8. Kumar, A., Bhayana, S., Singh, P. K., Tripathi, A. D., Paul, V., Balodi, V., & Agarwal, A. (2025). Valorization of used cooking oil: challenges, current developments, life cycle assessment and future prospects. Discover Sustainability, 6(1), 1-31. https://doi.org/10.1007/s43621-025-00905-7
9. Lopresto, C. G. (2025). Sustainable biodiesel production from waste cooking oils for energetically independent small communities: an overview. International Journal of Environmental Science and Technology, 22(3), 1953-1974. https://link.springer.com/article/10.1007/s13762-024-05779-2
10. Mannu, A., Di Pietro, M. E., Petretto, G. L., Taleb, Z., Serouri, A., Taleb, S., ... & Mele, A. (2023). Recycling of used vegetable oils by powder adsorption. Waste Management & Research, 41(4), 839-847. https://journals.sagepub.com/doi/pdf/10.1177/0734242X221135336
11. Mannu, A., Flores, P. A., Vangosa, F. B., Di Pietro, M. E., & Mele, A. (2025). Sustainable production of raw materials from waste cooking oils. RSC Sustainability, 3(1), 300-310. https://pubs.rsc.org/en/content/articlelanding/2025/su/d4su00372a
12. Omidvar, M., Malayeri, M. R., Farshchi Tabrizi, F., & Doroodmand, M. M. (2023). Investigation of

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue IX September 2025

used cooking oil on the formation of FOG deposits in sewer line clogging. Environmental Science and Pollution Research, 30(7), 18325-18339. https://link.springer.com/article/10.1007/s11356-022-23480-0

13. Shi, H., Zhang, L., Pan, D., & Wang, G. (2024). Deep reinforcement learning-based process control in biodiesel production. Processes, 12(12), 2885. https://www.mdpi.com/2227-9717/12/12/2885
14. Velmurugan, A., & Warrier, A. R. (2022). Production of biodiesel from waste cooking oil using mesoporous MgO-SnO2 nanocomposite. Journal of Engineering and Applied Science, 69(1), 92. https://jeas.springeropen.com/articles/10.1186/s44147-022-00143-y