

Sustainable Aquaculture Systems: Microcontroller–Driven Solar–Powered Fish Feeder

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Abstract. This research focuses on the development and implementation of a solar-powered automatic fish feeder using Arduino and a microcontroller to optimize feeding processes in aquaculture systems. The primary objective is to create an efficient and effective prototype that improves fish farming productivity while aligning with the Sustainable Development Goals (SDGs). The system integrates photovoltaic panels, a 12V 40Ah battery, and a 200W solar panel, controlled by a solar charge controller to ensure continuous, sustainable energy. The Arduino microcontroller serves as the central processing unit, programmed to operate a servo motor that opens and closes the feed channel at precise intervals, dispensing 3kg of feed per day. The feeder operates on two feeding schedules: 8:30–9:00 AM and 3:30–4:00 PM, each involving three cycles with 1–minute intervals to ensure efficient consumption of feed. By utilizing solar power, the system contributes to SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action), while promoting sustainable aquaculture practices that support SDG 14 (Life Below Water). The design also aims to improve food security (SDG 2: Zero Hunger) and provide technological innovation in fisheries (SDG 9: Industry, Innovation, and Infrastructure). This solar-powered fish feeder represents a practical solution for enhancing the productivity and sustainability of aquaculture, offering a low-cost, eco-friendly alternative to traditional feeding methods.

Keywords: Aquaculture systems, Microcontroller, Photovoltaic panel, Solar Powered, Fish farming innovation

1. Introduction

The modern fish farmer constantly faces a conflict: the difficult struggle of balancing personal commitments—from crucial business trips to much-needed family vacations—with the non-negotiable, daily need to feed their stock. Every farmer knows that inconsistent feeding means lower yields and jeopardized income. Beyond personal absence, an even greater threat is the unpredictable power grid, where a simple outage can disrupt the feeding schedule and stunt fish growth.

Automatic fish feeders (AFFs) have emerged as essential tools for consistent and precise feeding (Susilawiti et al., 2023). The researcher chose this study because solar-powered AFFs offer a unique way to provide optimal nutrition, minimize manual labor, and significantly boost overall efficiency and sustainability. Therefore, this project focuses on designing and developing a Solar-Powered AFF for a typical medium-sized concrete pond (4m x 5m). Our innovation integrates solar energy to guarantee the system never misses a meal, operating autonomously and efficiently without constant human supervision. Ultimately, this research seeks to provide a reliable, transformative solution that boosts operational efficiency and, most importantly, provides the fish farmer with the peace of mind that their livelihood is protected, even when they step away.

2. Methodology

The study utilizes the Hannafin–Peck Development Model (1987) as the primary framework for designing and developing the solar-powered fish feeder. This model involves three major stages—needs assessment, design, and development/implementation—each followed by evaluation and revision to ensure continuous improvement. By applying this structured approach, the study ensures systematic planning, testing, and refinement of the device to achieve efficiency and sustainability in aquaculture operations (Pappas, 2016).

2.1. *Sampling Procedure*

In this study, we ensured every voice mattered by using a **random sampling method**. This wasn't just a technical requirement; it was a promise of fairness and inclusion, giving every potential respondent an equal shot at sharing their perspective. By deliberately seeking feedback that was unbiased and representative, we gathered crucial input from all key players: the academic instructors (BIT–EET and agriculture), the technical aqua-culturists or engineers, and, most importantly, the seasoned fisherfolk from the Provincial Satellite Tilapia Hatchery. This inclusive approach guarantees that the final device design reflects a well-rounded and trustworthy consensus.

2.2. Respondents

A total of 26 respondents took part in evaluating the solar-powered automatic fish feeder. They included **BIT-EET instructors, agriculture instructors, aqua-culturists or engineers, and fisherfolk** from the Provincial Satellite Tilapia Hatchery. The participants were chosen through random sampling to ensure fair representation and an unbiased evaluation of the device’s design, build quality, durability, usability, performance, and safety.

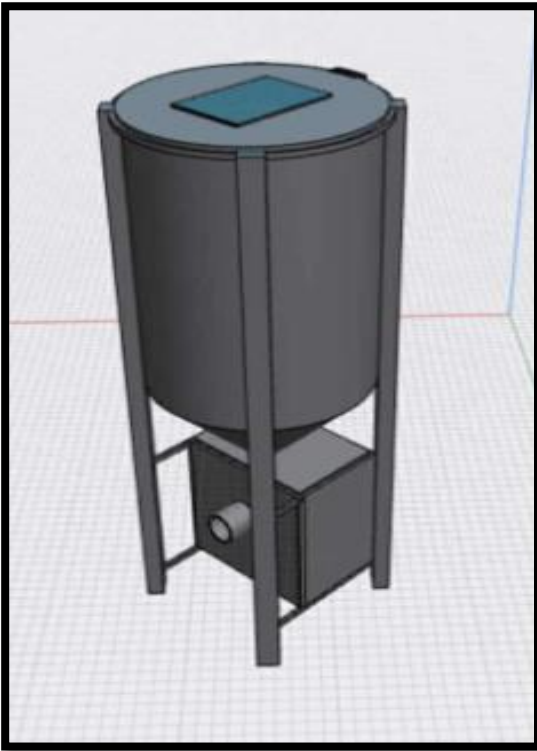
No.	Respondents	Qty
1	<i>BIT-EET Instructors</i>	5
2	<i>Agriculture Instructors</i>	5
3	<i>Aquaculturists/Engineers (Experts)</i>	6
4	<i>Fisherfolk from the Provincial Satellite Tilapia Hatchery</i>	10
Total		26

Note. This table presents the distribution of respondents who evaluated the solar-powered automatic fish feeder according to their professional groups.

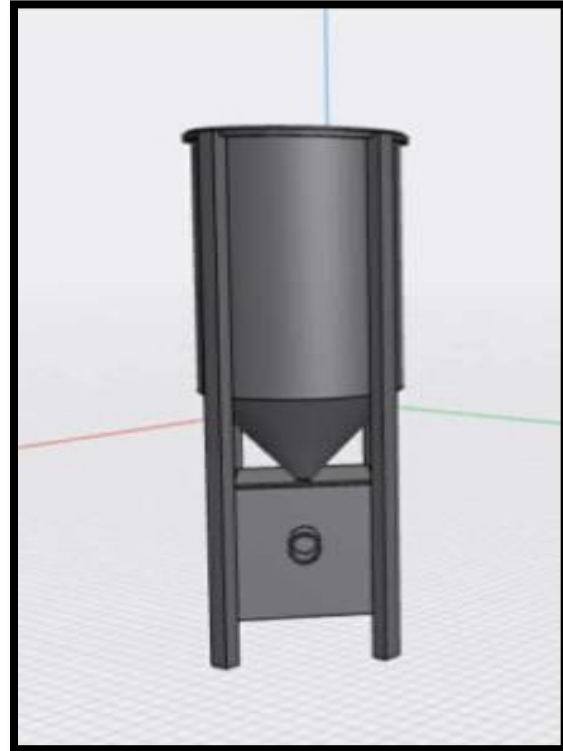
2.2.1 Research Site

The research is conducted at the Provincial Satellite Tilapia Hatchery in Brgy. Reserva, Baler, Aurora, where fisherfolk adhere to a regular feeding schedule for their fish. They typically feed their tilapia from Monday to Friday, providing 2 kg of fish feed per session, twice daily, between 8:30 – 9:00 AM and 3:30 – 4:00 PM. However, during the weekends, the fisherfolk will be off duty, which may result in delays in the regular feeding process.

2.3 Sample Drawing of the device



(Figure 1)



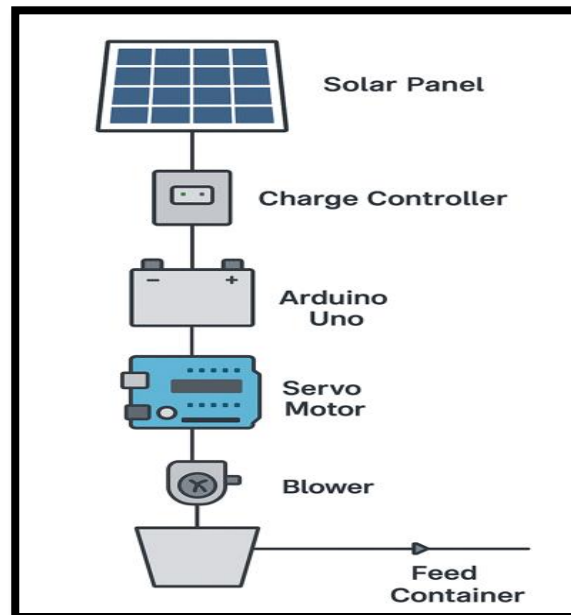
(Figure 2)

The Solar-Powered Automatic Fish Feeder (Figure 1&2) is designed to automate fish feeding using solar energy. The system is composed of a solar panel, charge controller, 12V battery, Arduino Uno microcontroller, servo motor, blower, and feed container.

During operation, the solar panel converts sunlight into electricity, which is stored in the battery through the charge controller. The Arduino Uno controls the servo motor that opens and closes the feed outlet based on a programmed schedule. The blower helps spread the feed evenly across the pond. The feeder dispenses around 3 kilograms of feed per day in two feeding times — 8:30–9:00 AM and 3:30–4:00 PM — each with three cycles and one-minute intervals to ensure proper feeding.

This system helps fish farmers maintain a regular feeding schedule even without electricity or human supervision. It supports sustainability by using solar energy and contributes to SDG 2 (Zero Hunger), SDG 7 (Affordable and Clean Energy), and SDG 13 (Climate Action) (United Nations, 2015).

2.4 Sample schematic of the device



The schematic diagram of the solar-powered automatic fish feeder illustrates the interconnection of essential components that work together to automate fish feeding using renewable energy. The system begins with the solar panel, which converts sunlight into electrical energy. This energy flows into the charge controller, which regulates voltage and prevents overcharging of the battery. The stored energy in the battery powers the Arduino Uno, which serves as the brain of the system. The Arduino is programmed to control the servo motor that opens the feeding channel and activates the blower to distribute the fish feed evenly into the pond. The feed container holds the fish feed, which is dispensed at set intervals, ensuring consistent feeding schedules even during the absence of the operator.

2.4.1 Components

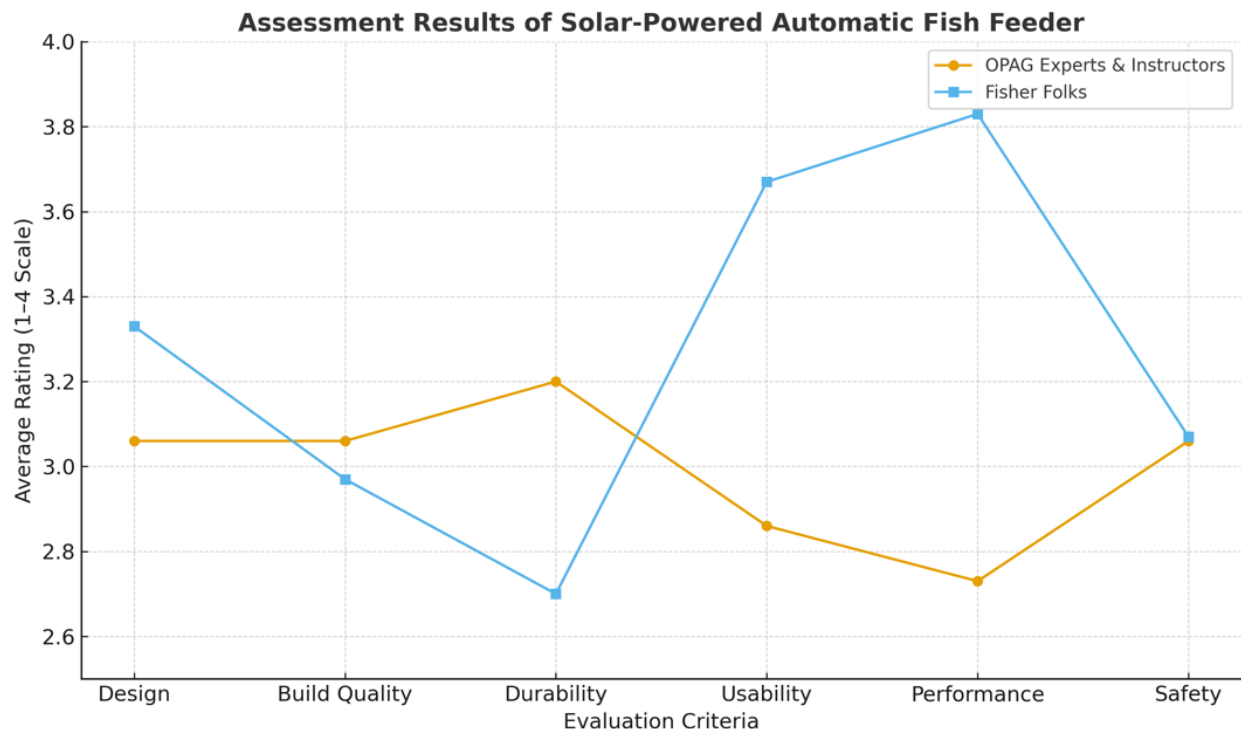
1. Solar Panel – collects sunlight and generates power
2. Charge Controller – regulates power going to the battery
3. Battery (12V) – stores electrical energy
4. Arduino Uno – controls the timing and operation
5. Servo Motor – opens and closes the feeding gate
6. Blower – distributes feed in the pond
7. Feed Container – holds the fish feed

3. Results and Discussion

The study aims to develop a solar-powered automatic fish feeder and assess it based on design, build quality, durability, usability, performance, and safety.

The study found that the overall test that is being conducted by OPAG experts, EET Instructors, and Agriculture Instructors on the Design averaged **3.06** which means the device has a **Good Quality Design**, the Built Quality averaged **3.06** which means that the solar-powered automatic fish feeder has a **Good Built Quality**, the Durability averaged **3.2** which means the solar-powered automatic fish feeder is **Durable**, the Usability averaged **2.86** which means the solar-powered automatic fish feeder is **Usable**, the Performance averaged **2.73** which means the solar-powered automatic fish feeder is **efficient** and the Safety averaged **3.06** which means the solar-powered automatic fish feeder is **Safe**.

The study found out that the overall test that is being conducted by the Fisher Folks on the Design averaged **3.33** which means the device has a **Good Quality Design**, the Built Quality averaged **2.97** which means that the solar-powered automatic fish feeder has a **Good Built Quality**, the Durability averaged **2.70** which means the solar-powered automatic fish feeder is **Durable**, the Usability averaged **3.67** which means the solar-powered automatic fish feeder is **Usable**, the Performance averaged **3.83** which means the solar-powered automatic fish feeder is **efficient** and the Safety averaged **3.07** which means the solar-powered automatic fish feeder is **Safe**.



The chart clearly shows how differently the solar-powered automatic fish feeder was experienced by its technical reviewers and its end-users. While both groups gave positive feedback, the fisherfolk—the men and women who depend on fishing for their livelihood—rated it significantly higher in usability and performance. Their feedback wasn't just a rating; it was a testament that the feeder saves them time and labor where it matters most: on the water. The OPAG experts, on the other hand, established a trusted technical baseline, confirming the device's foundational integrity with consistent ratings on design, build quality, and safety. Ultimately, this comparison proves that real-world experience is the final arbiter of quality. Listening to the fishers humanizes the design process, ensuring that our technology is not just innovative, but genuinely useful and transformative for the people who need it most.

4. CONCLUSION

Based on the result of the study, the following conclusions were drawn:

1. The Solar-Powered Automatic Fish Feeder was Good Quality Design, Good Built Quality, Durable, Usable, Efficient, and Safe based on the result asses by OPAG experts, EET Instructors, Agriculture Instructors, and Fisher Folks.
2. The Solar-Powered Automatic Fish Feeder is easy to build and use.
3. The Solar-Powered Automatic Fish Feeder can operate efficiently with AC and DC current.
4. The Solar-Powered Automatic Fish Feeder can be used in medium and small-scale concrete fish ponds.
5. The Solar-Powered Automatic Fish Feeder needs improvement if used in large-scale fish ponds.
6. The building, manufacturing, materials, construction, and organization of the apparatus need to be improved.

5. RECOMMENDATION

Based on the result the following recommendations were drawn:

1. The experts recommended several improvements: adjusting panel orientation, implementing a manual flow control fuse for hopper distribution, considering a larger feed container for scalability, enhancing construction materials, ensuring water sealing, increasing blower airflow for better feed distribution, and using smooth stainless-steel materials for distribution pipes.
2. They also suggested modifying solar panel mounting for adjustable angles based on area or pond needs, refining the distribution duct indicators, adding a power-off feature for the inverter or system post-feeding or during idle periods, adapting servo motor openings for blower integration, adjusting blower output for wider fish feed dispersion, and incorporating mobility wheels. Additionally, the researchers proposed installing a monitoring camera on the device for future research purposes.

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