3RD DLSU SENIOR HIGH SCHOOL
RESEARCH CONGRESS
REFRAMING POSSIBILITIES THROUGH RESEARCH AND INNOVATION FOR THE BETTER NORMAL
APRIL 29 - 30, 2021

Designing an Aquaponics System integrated with a Solar-powered Arduino Aquatic Feeder for Village Farmers

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ABSTRACT

Water is a limited resource due to continuous population growth and consumption; hence, water usage must be optimized especially in agriculture. This form and function concept development research of a recirculating aquaponics system aimed to fill the research gap for an agricultural system with minimal human interference. The researchers interviewed agricultural growers to identify problems of existing systems and addressed these issues through designing aquaponics systems that incorporated Arduino Uno sensors for regulating fish feeding as well as solar panels in generating renewable energy. Each aquaponics design had been evaluated based on the criteria: Ergonomic Function, Replicability, and Personalization of Design through a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis. The researchers then designed the final set-up via the Fusion 360, an open-source 3D creation suite.

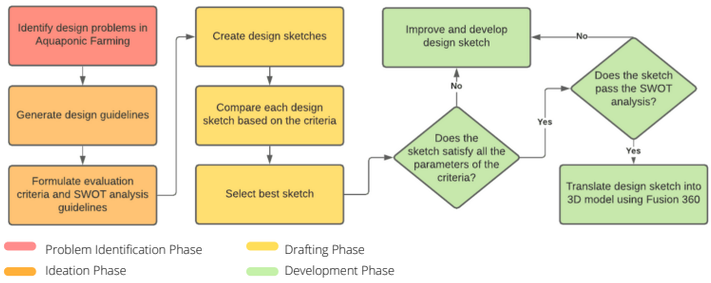
I. INTRODUCTION

Traditional agricultural systems inefficiently waste nutrients and water, thus the agriculture sector accounts for over 80% of Philippine water consumption (Inocencio & Barker, 2018). Technical improvements must then improve food production productivity in developing countries (Puteri Edaroyati et. al. 2017). By combining hydroponics with aquaculture, aquaponics systems emerged as a novel concept.

Even then, there are disadvantages to this system's requirements such as accessibility to sunlight and electricity, expensive materials, and maintenance costs from the fish feed and electric requirements. To enhance productive capacity, the proposed design must minimize the need for human intervention and energy usage by installing a renewable energy source and a fish feeder. Periodically-interspersed fish feeding may be dispensed at user-set timings of the day through the invention of Riduan, M. S. (2015), and Robotica DIY. (2019). The Arduino Uno fish feeder assists in the maintenance of the Oreochromis niloticus (Tilapia) aquaculture. Solar panels may power the system to reduce carbon footprint and lower operating expenses.

This research aimed to design and determine which single-loop aquaponics system incorporating a solar-powered Arduino fish feeder is most suitable in terms of Form Replicability, Personalization of Design, and Ergonomic Function then model the proposed design on Fusion 360.

II. METHODOLOGY



CRITERIA

Relevant Criteria	Characteristics	Desired Characteristics
Ease of Assembly	Materials used	Must be common and easy to acquire locally
	Number of parts for assembly	Few
	Properties of parts	Lightweight but durable
	Time for assembly	1-2 hours
Compactness	Minimum and maximum fish threshold	3-6 tilapia per 12-24 gallons of water
	Minimum and maximum crop threshold	4-5 crops per row
	Total surface area of fish tank	Must handle large volumes of water and provide easy access for fish
	Total surface area of grow bed	Must accommodate at least 8 crops per plant species
Tank Flexibility	Tank layout	Cylindrical/conical design
Grow bed Compatibility	Grow bed layout	Vertical orientation
	Spacing between crops	Lettuce seeds: 4-6 inches apart Tomato seeds: 6-12 inches apart
Solar Panel Efficiency	Power rating	Solar panel power must be adequate for the required electricity consumption
	Set-up	CIS or amorphous silicon solar panels
Arduino Software Functionality	Code configuration	Replicable, easy to understand, and functional for the intended purpose

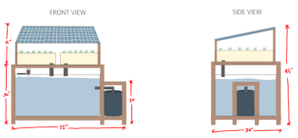
BASIC COMPONENTS OF AQUAPONICS SYSTEM

Basic Components	Brief Description
90° Elbow Connector	Used to connect PVC pipes inside the swirl filter
Bell Siphon	Used to regulate the water level in grow beds without human intervention
Bucket	Container for swirl filter
Bulkhead Fitting	Used to avoid leakage in swirl filter
Fish Tank	Used as the container for fishes
Grow Bed (with media)	Used as containers for plants
PVC Pipe	Used for passage of water in and out of swirl filter
Solar Battery	Used for storage of unused solar energy
Solar Panel	Used to power the water pump and the fish feeder
Water Pump	Device for moving water from the tank to the swirl filter

PARTS OF ARDUINO FISH FEEDER

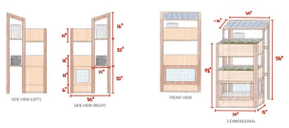
Arduino Components	Brief Description
Arduino Uno	Responsible for reading inputs and turning them into outputs
Servo Motor	Used to rotate the fish feed at a time interval
Jumper Wires	Used to connect the servo motor to the Arduino Uno
Solar Charger	Used to supply electricity to the Arduino Uno and the batteries

III. RESULTS AND DISCUSSION



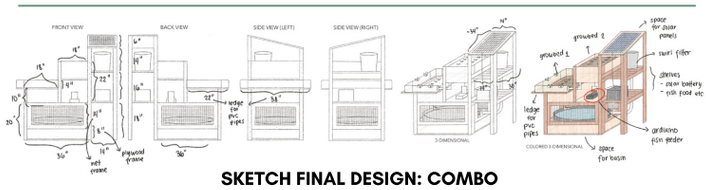
DESIGN 1: HORIZONTALLY WIDE

DESIGN 3: STAIRCASE



DESIGN 2: VERTICALLY TALL

	Advantages	Disadvantages
Design 1	- Can accommodate the maximum threshold for fishes and plants	- The system will take up a considerable amount of space
Design 2	- Netting will act as a barrier for the fish tank	- Crops may not receive sufficient sunlight
Design 3	- Staircase design may allow plants to receive sufficient sunlight	- Overall design is not aesthetically pleasing and is too tall



SKETCH FINAL DESIGN: COMBO

CAD FINAL DESIGN: COMBO

SWOT OF FINAL DESIGN

Parameters	Ergonomic Function	Personalization of Design	Replicability
Strengths	- Precoded Arduino code	- Cylindrical fish tank for self-cleaning through efficient water flow. - PVC pipes were used to carry out NFT for more crops to be grown - Pipes maximized space usage	- Grow beds accommodated eight crops, while the PVC pipes accommodated six crops. - Around 4-6 tilapia may be accommodated if the basin is approximately 34 inches wide and 18 inches deep.
Weaknesses			- Framework requires plenty of wood
Threats	- Fixed time interval to feed fishes		- Overall system might take up a considerable amount of space
Opportunities	- Solar panels were slightly tilted on top of the system to maximize sunlight captured - The top shelf carried the swirl filter, while the bottom may be for other storage purposes	- Two grow beds modelled in a stair-stepped fashion to allow grow beds to receive enough sunlight	

IV. CONCLUSION

The researchers conceptualized three designs of theoretical single-loop aquaponics systems incorporating a solar-powered Arduino fish feeder. Duly combining the strengths of the three designs, a final CAD model had then been generated through Fusion360 software. For a total of 22 crops, the wooden plywood framework supports two grow beds with eight crops each and PVC pipes for the nutrient film technique of six crops. Around four to six tilapia may be accommodated if the bug-netted basin is approximately 34 inches wide and 18 inches deep. For future research, it is recommended to construct a built-to-scale prototype of the final design.

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