



BUST LL MVPs

Outdoor aquaponic system



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1. Overview

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Innovation Actor: BUST LL

Location: BAMENDA-CAMEROON

Keywords: no screen/green house, outdoor, aquaponics, affordability, local materials

1.1. Abstract

The outdoor aquaponic system utilizes a tarpaulin fish tank, designed to create a sustainable environment for fish and plants. By integrating a newly adapted filtration system, comprised of two half barrels filled with three layers of gravel, solid waste from the fish tank is effectively filtered before reaching the PVC grow beds. This prevents sludge from clogging plant roots, ensuring adequate oxygen and nutrient absorption, leading to improved plant performance. The system operates in a closed-loop, recycling water between the fish tank and grow beds, promoting a healthy ecosystem.

1.2. Photo



Figure 1: BUST outdoor aquaponic system with added filtration unit

The system consists of fish tank, filtration system, newly added filtration using half barrels filled with three layers of gravel, designed to filter solid waste before it reaches the grow beds, grow beds, PVC pipe structures where plants are cultivated utilizing the nutrient-rich water from the fish tank. The filtration system design has three-layer gravel filtration. The upper layer has the largest gravel size, allowing for initial filtration of larger solids and preventing clogging. The middle layer consists of medium-sized gravel, providing additional filtration and supporting beneficial microbial growth. The third and bottom layer has smaller gravel, which captures fine particles and enhances water flow, ensuring clear water is delivered to the grow beds. Water flows from the fish tank to the filtration system, where solids are filtered out. The filtered water is then directed to the grow beds, providing

plants with essential nutrients while preventing root clogging. After passing through the grow beds, the water is returned to the fish tank, creating a closed-loop system.

Value proposition of outdoor aquaponic with adapted filtration system

The filtration system prevents sludge from clogging roots, allowing for better oxygen flow and healthier plant growth. Plants receive a consistent supply of nutrients from the fish waste, promoting vigorous growth and higher yields.

System maintenance is decoupled from main grow bed crop cycle, allowing for more flexible cleaning of the filter unit.

1.3. Motivation and Challenges addressed

Problems address by the aquaponic system MVP

In traditional aquaponics systems, fish waste can accumulate and create sludge that clogs plant roots, leading to oxygen deprivation and poor plant health. The filtration system effectively removes solid waste before it reaches the grow beds, preventing root clogging and ensuring that plants receive adequate oxygen and nutrients. Clogging roots can hinder nutrient uptake and reduce plant performance, leading to lower yields and unhealthy crops. By filtering out solids, the system promotes better aeration and nutrient availability, resulting in healthier plants with improved growth rates.

Concept of the idea

The idea to develop this system likely emerged from observing common challenges faced in existing aquaponics setups, particularly the issue of waste buildup and its negative impact on plant health. The adaptability of the system to incorporate filtration and other innovations reflects a responsive approach to improving agricultural practices based on real-world experiences and feedback. A commitment to exploring innovative farming techniques would drive the search for solutions that enhance efficiency and sustainability in agricultural practices.

1.4. Feedback process

Interaction between the living lab and innovation actors

The living lab organizes hands-on workshops where farmers and partners learn about innovative agricultural techniques, including system setup, maintenance and best practices in aquaponics and hydroponics. Based on the specific needs and backgrounds of participants, the living lab develops customized training sessions that cater to different levels of experience and knowledge. The innovation was not yet adapted by an innovation actor.

2. Implementation

2.1. MVP Design

Key components of the MVP and major design decisions of the outdoor aquaponic system with an adaptable filtration system.

Tarpaulin fish tank filtration system, grow bed, PVC pipes, submersible pump to circulate water from the fish tank to the filtration system and grow beds, air stones or diffusers, water testing kits.

Major design decisions

The choice to use a three-layer gravel system was made to enhance the filtration process, allowing for effective separation of larger solids first, followed by finer filtration. Utilizing repurpose half barrels minimizes costs while providing adequate space for filtration, ensuring that water flows naturally from the fish tank through the filtration system to the grow beds reduces reliance on additional pumps and energy consumption.

2.2. Operation and usage of the outdoor aquaponic system with adapted filtration

Setup and installation

- Position the tarpaulin fish tank securely and ensure it is level.
- Assemble the filtration system using half barrels filled with the three layers of gravel for effective solid waste filtration.
- Install the grow beds (PVC pipes) at a suitable height for easy access and maintenance.
- Fill the fish tank with water, ensuring it is treated and dechlorinated if necessary.
- Choose suitable fish species (e.g. tilapia or catfish) based on local climate and market demand.
- Introduce fish gradually to avoid overloading the system.
- Monitor water quality as fishes are added.
- Start seeds in grow cups or trays using a suitable growing medium (e.g. sawdust is the recommended growing medium in BUST LL).
- Once seedlings are established, transplant them into the grow beds, ensuring they are spaced adequately for growth
- Use a submersible pump to circulate water from the fish tank to the filtration system and then to the grow beds.
- Ensure the pump is running continuously to maintain water flow
- Water passes through the gravel layers in the filtration system, where solids are filtered out and then flows to the grow beds, providing nutrients to the plants.
- After passing through the grow beds, the water returns to the fish tank, completing the closed-loop system.
- Regularly test water parameters (pH ammonia, nitrite, nitrate) to ensure optimal conditions for both fish and plants.
- Adjust feeding and water chemistry as needed based on test results.
- Inspect and clean the filtration system periodically to prevent clogs and ensure efficient operation.
- Monitor fish health and behavior, checking for signs of stress or disease
- Harvest plants when they reach maturity, using scissors or shears to cut them from the grow bed
- When fish reach market size, harvest them following humane practices and local regulations.
- Use the system as a demonstration site for training workshops, allowing farmers and students to learn about aquaponic and hydroponics
- Engage with participants to gather feedback and insights, using this information to improve system design and operation.

2.3. Bill of materials and required tools

Table 1. A table of materials required to build one unit of the MVP including costs

Item	Quantity*	Unit cost (FCFA)	Total cost (FCFA)
Tarpaulin plastic	68 square meters	1400	95200
PVC pipe 100	7	5500	38500
Aquarium pipe	2	50000	100000
Wood 2X6	12	3300	39000
Fish net	12 square meters	800	9600
Blue barrel	1	17000	17000
Gravel	4 wheelbarrows	3500	14000
Sawdust	15 kg	200	3000
Disposable gloves	5 pairs	150	750
Iron platform	6	2500	15000
Grow cups	138	25	3450
Tank connector	4	1500	6000
Valve 32mm	4	200	800
Reducer 100 X 63	12	1100	13200
Valve ¾	30	500	15000
Adaptors 32mm	8	300	2400
Elbow 32mm	16	300	4800
Tee 32mm	6	400	2400
Pipe 32mm	2	2200	4400
Valve 3/4	4	500	2000
Elbow ¾	21	200	4200
Plug 63mm	8	800	6400
Tee ¾	3	200	600
Pipe ¾	1	1200	1200
Pipe 63mm	1	3500	3500
Binding wire	1 roll	1000	1000
Nails	2kg	1200	2400
Tube 20	1	3000	3000
Barbet	1	1000	1000
		Total	409,800

Table 2. Tools required

Item	Quantity	Unit cost (FCFA)	Total cost (FCFA)
Carpenter harmer	1	2500	2500
Carpenter saw	1	3500	3500
Electrical perforator	1	1500	1500
		Total	7,500

3. Economics

3.1. Business concept for operating the outdoor aquaponic system

This business model focuses on sustainable food production, community engagement and educational opportunities. By leveraging local markets, offering diverse revenue streams and building strong partnerships, the business can thrive while contributing to food security and environmental sustainability.

4. Future Improvements

4.1. SWOT analysis of the MVP

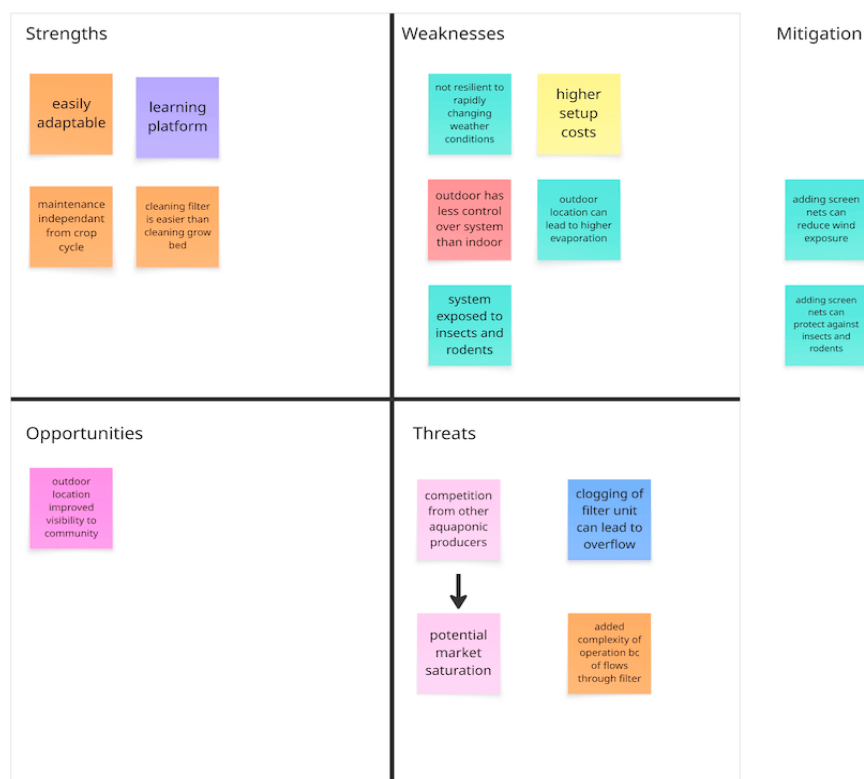


Figure 2: SWOT – BUST LL – Outdoor Chop & Flip aquaponics with added filtration unit

Strengths

- The MVP utilizes a closed-loop system that recycles water and nutrients, minimizing waste.
- Reduces reliance on chemical fertilizers and pesticides promoting environmentally friendly practices.
- The system can be easily expanded or adapted based on user needs and available resources, allowing for flexibility.
- The MVP also serves as a hands-on learning platform for farmers, students and researchers, fostering innovation in agricultural practices

Weaknesses

- Outdoor systems are subject to unpredictable weather conditions that can affect fish and plant health.
- High setup costs for infrastructure, equipment and training programs.
- The system has limited control over environmental factors compared to indoor systems.
- Successful operation requires a certain level of expertise in aquaponics and hydroponics, which may deter some users.
- Some plants may not thrive in aquaponics systems, limiting the diversity of produce that can be offered.

Opportunities

- Increasing consumer interest in local, sustainable food sources presents a significant market opportunity for fresh produce and fish.

- Collaborating with schools and universities can enhance educational offerings and provide additional resources and support.
- Strengthening community ties through educational programs and local partnerships can enhance the business's visibility and support.

Threats

- The emergence of other local farms and aquaponics systems could saturate the market and impact profitability.
- Climate change and water availability could impact the viability of aquaponics systems and crop production.
- As more urban farms and aquaponics systems are established, the risk of market saturation increases, potentially affecting profitability.

4.2. Optimization

Approaches to improve the outdoor aquaponic system MVP

- Simplify the setup and operation process by providing clear, step-by-step guides and instructional videos.
- Explore alternative filtration methods, such as biofilters or mechanical filters to improve solid waste management and enhance water quality.
- Implement sensors for real-time monitoring of pH, temperature and nutrient levels, with automated adjustments to maintain optimal conditions.
- Experiment with different plant species to identify those that thrive in the aquaponic environment, increasing the diversity of produce available.
- Incorporate vertical grow systems to maximize space and allow for a wider variety of crops.
- Offer regular workshops to educate users on best practices, troubleshooting and advanced techniques in aquaponics.
- Create a platform for users to share experiences, tips and success stories, fostering a supportive community.
- Consider using solar panels or wind turbines to power the system, reducing operational costs and environmental impact.
- Explore methods to further optimize water use, such as rainwater harvesting or greywater recycling.
- Regularly collect feedback from users to identify pain points, suggestions and areas for improvement.
- Test new features or designs with a small group of users before full-scale implementation, allowing for iterative improvements.
- Collaborate with agricultural researchers or universities to stay at the forefront of aquaponics advancements and innovations
- Engage with aquaponics specialists to refine the system design and operation based on best practices.

4.3. Threat mitigation

Ideas to mitigate identified threats to the outdoor aquaponic system:

- Strengthen ties with the local community through events, workshops and partnerships with local businesses to build a loyal customer base.

- Form alliances with other local farmers and aquaponics systems to share resources, reduce costs and create a united front in marketing efforts.
- Establish multiple income sources such as direct sales, workshops and consulting services to reduce reliance on any single revenue streams.
- Design the system to be adaptable to varying climate conditions, including protective structures (like greenhouses) to mitigate extreme weather effects.
- Employ advanced water management practices, such as rainwater harvesting and efficient irrigation methods, to ensure water availability during shortages.
- Incorporate diverse plant and fish species to enhance resilience against pests and diseases, reducing vulnerability to environmental changes.

5. Appendices

5.1. References to experiments

Growth performance of green beans and the African Catfish, *Clarias gariepinus* in an outdoor aquaponic system was measured within the framework of a Master's degree Thesis at BUST in 2024. The integration of *Phaseolus vulgaris* (green beans) in an outdoor aquaponic system utilizing *Clarias gariepinus* (African catfish) demonstrated high productivity with a harvest weight of 6335.5g and effective biomass utilization. These results suggest that aquaponics provides a more efficient nutrient delivery system and optimized growing conditions, leading to enhanced plant growth and yield. The cultivation of *Phaseolus vulgaris* and *Clarias gariepinus* in one water cycle resulted in a sustainable and efficient nutrient cycle, which not only enhanced plant growth but also improved the overall health and growth rate of the fish. Outdoor aquaponic systems can therefore be recommended to farmers who cannot afford a screen/green house. Further research is however necessary, e.g. if there are differences in the rainy and dry seasons with different pest and disease control needs.

5.2. Photographs and additional Documentation

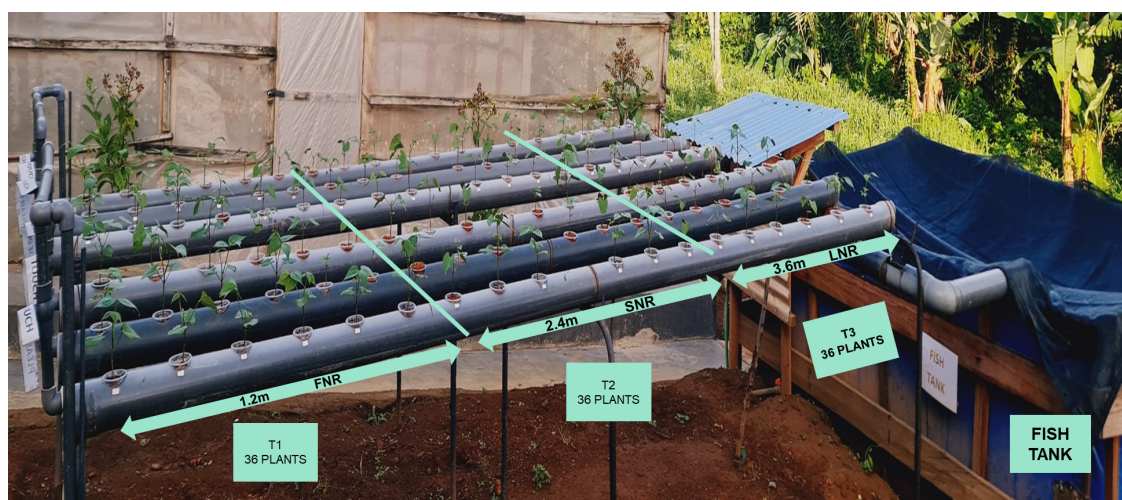


Figure 3: Green beans experiment carried out in the outdoor aquaponic system at BUST (June 2024)