



Minimum Viable Product (MVP) Documentation

Upscaled NFT Aquaponics

Living Lab NUSL



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1. Overview

Principal Investigator: Prof. Dr. Olufemi Julius Olapade

Co-investigators: Annmarie Bangura

Innovation Actor: Gibrilla S. Jalloh

Location: Njala University Living Lab

Keywords: Nutrient Film Technique, African Catfish (*Clarias gariepinus*), Okra (*Abelmoschus esculentus*), Outdoor Aquaponic

1.1. Abstract

The MVP demonstrates that an outdoor aquaponics system, particularly the Nutrient Film Technique (NFT), combining aquaculture with hydroponics is a sustainable and efficient farming method. This study investigated the performance of an outdoor NFT aquaponic system combining *Clarias gariepinus* (African catfish) and *Abelmoschus esculentus* (okra), focusing on biological efficiency and economic feasibility. It achieved favorable fish growth, stable condition factors, high okra yields, effective nutrient use, stable water quality while comparing aquaponics with conventional farming methods. Economically, the system proved competitive with traditional farming. The findings support adopting this system to enhance productivity and sustainability, with recommendations for policy support and farmer training.

1.2. Photo



Figure 1: NUSL upscaled NFT aquaponic system

1.2. Motivation and Challenges addressed

The MVP addresses the critical challenges of land, and water scarcity faced by traditional agriculture, especially in urban and peri-urban areas of developing countries like Sierra Leone (UN, 2014). With rapid urbanization and a projected doubling of the global urban population by 2050, there is an urgent

need for sustainable food production methods that requires less space and resources. Despite the promise of aquaponics, particularly NFT aquaponics system combining species like *Clarias gariepinus* (African catfish) and *Abelmoschus esculentus* (okra), practical data on their performance and economic viability in these contexts remain limited. The idea to develop this MVP was conceived to fill these knowledge gaps, providing evidence-based insights into the biological efficiency, system management, and profitability of aquaponics. By demonstrating its potential as a resources-efficient and climate-smart alternative to conventional farming, the MVP aims to support small scale farmers, policy makers, and investors in making informed decisions that promote food security, poverty alleviation, and sustainable development in resources-constrained environments.

1.3. Feedback process

The Njala University Living Lab (LL) collaborates closely with the innovation actor, by offering a practical setting where aquaponics concepts maybe tested, enhanced, and modified before farmers adopt them. The system was tested using locally available fish like *Clarias gariepinus* and crops such as okra, by providing space, supervision, and equipment. The innovation actor observes and examines what works and what has to be modified to fit local farming conditions in the practical setup. The innovation actor interacts frequently with the lab and exchanged valuable information. The LL team provides technical support on issues such as nutrient balance, water flow, and fish health. Farmers who visit the LL and offer feedback based on their experiences might help design a system that is easier to use and more appropriate for small-scale users.

Due to this partnership, early problem solving, risk reduction, and increased trust in the technology were all made possible. In addendum, this partnership helps the innovation actor in demonstrating that aquaponics can effectively grow fish and vegetables despite resource and space constraints. The LL therefore serves as a conduit between new technology and farmers, enabling adoption and support communities in realizing the true merit of aquaponic farming in Sierra Leone.

2. Implementation

2.1. MVP Design

The main goal of setting up the aquaponic system was to make it simple, useful, and accessible to all. Each NFT pipe was constructed long enough (5.63 meters / 18.7 feet) to accommodate multiple plants comfortably, such that the planting holes (30 cm) positioned to enable the crops to flourish with no competition for space. This enables farmers to easily maintain a smooth water flow, clear the pipes, and inspect the plants. Allowing some space between them promotes stronger vegetative growth and lessens inadequate air circulation and overcrowding, enabling enough space for roots to spread out inside the NFT pipe, and further optimize roots health. Farmers can adjust the number of plants-based courtesy of their individual requirements with consideration that healthy spacing promotes greater overall growth. Considering the farm size, the design can be adjusted up or down. While some farmers would choose a large arrangement for greater output, others might only want a few pipes close to their backyard.

The pipes are installed with a slight slope roughly a 2% drop to maintain smooth water flow, which entails raising one end slightly higher than the other. This tiny tilt guarantees that the water flows evenly throughout without flooding or drying out the plants. In order to avoid unequal water distribution, it is also crucial to level the pipes from side to side. Using basic supports like blocks, bricks, or wooden sticks, farmers can easily set the slope.

This was based on what was most effective during use, this arrangement has already undergone a number of adjustments. For instance, improving the water movement, changing the pipe length, and increasing the plant spacing all contributed to the system's better management. As farmers become familiar with how the system function in their particular settings, they can implement this easy adjustment as the ultimate goal is to provide a design to farmers that they can easily and immediately understand and modify it to fit their specific farming method with little to complex requirements.

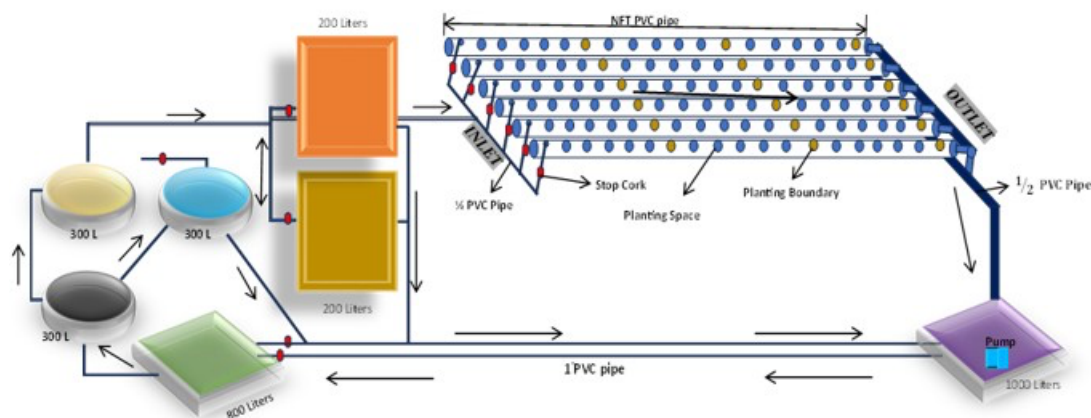


Figure 2: The MVP setup (Aquaponics System with NFT grow beds)

2.2. Operations

The Nutrient Film Technique (NFT) is one of the simplest and least expensive methods for growing vegetables in an aquaponics system. NFT allows plants roots to rest well in a shallow trickle of water rich nutrient coming directly from the fish tank. The water has all the natural nutrients that plants need, thus, farmers don't need to buy pricey fertilizer. Growth is rapid in this system since plants receive nutrients and oxygen simultaneously as water flow through the pipes gently and constantly promoting healthier crops and fish.

To achieve this, determining the slope accurately is crucial in the NFT system. The pipes shouldn't be very steep or entirely flat. A slope that allows the water to move gently from one end to the other is the best slope. Ensure that there is a steady water flow, by angled slightly the PVC pipes for drainage at a sloped of ($\approx 2\%$) with the plant holes positioned such that each plant receives adequate sunlight. A 2% slope is a gentle angle, ensure about a 2cm drop for every 1 meter of pipe, and angled at 90° the reducer on the other end (e.g. 4" to 1½" PVC reducer) to enabling the steadily movement of nutrient-rich water through the PVC pipe without pooling or leaving parts of the roots dry and always keeps water in the system even when there is electricity outbreak.

Additionally, levelling is crucial. The water flow becomes irregular if the pipes bend in the middle or tilt sideways. It's possible that some areas receive too little water while others receive too much. Farmers may prevent this by using basic equipment like a spirit level, a piece of wood, or even bottles or blocks placed beneath the pipes to support them. The system requires relatively little daily effort and is considerably easier to handle if the pipes are stable. The NFT system becomes extremely effective when the pipes are level and the slope is appropriate. Plants grow uniformly, oxygen enters the roots, and water flows smoothly. For crops like lettuce, okra seedlings, leafy greens, pepper, amaranth, and other quickly growing veggies, this arrangement works particularly well. It is useful for both tiny backyard farmers and larger installations because it is simple to clean, maintain, and modify.

2.3. Bill of materials and required tools

Table 1. Materials required to build an outdoor aquaponic system and costs

Item	Quantity*	Unit cost (€)	Total cost (€)
Fingerlings	75	0.22	16.25
NFT pipes (High Pressure)	6	36	216
IBC tank	2	145	290
Radial tank	1	29.71	29.71
Filter tank	1	29.71	29.71
Sludge tank	1	29.71	29.71
Tee 1"	12	0.45	5.4
Tee 1½"	12	0.45	5.4
Tee ¾"	12	0.22	2.64
Elbow 1"	24	0.37	8.88
Elbow 1½"	14	0.56	7.84
Elbow ¾"	20	0.22	4.4
Bend 1"	20	4.4	88
Stop corks 1"	5	2.6	13
Stop corks ¾"	10	2.6	26
Adapter 1"	16	0.93	14.66
Pipes ¾"	5	2.97	14.85
Pipes 1½"	3	4.64	13.92
Pipes 1"	5	4.09	20.45
Reducer 1" to ¾"	6	0.56	3.36
Reducer 4" to 1"	10	0.74	7.4
End cap 4"	10	0.93	9.3
90° elbow	12	0.67	8.04
¾ Tank connector	6	1.49	8.94
1" Tank connector	6	1.86	11.16
Solvent	4	2.04	8.16
Aquaponics rack	1	173.70	173.70
Silicon (white)	4	1.86	7.86
PVC taping thread	4	0.56	2.24
Cement blocks	24	0.6	14.5
Drilling machine & discs	1	52.1	52.1
Ark-saw blade	4	0.74	2.96
Adjustable wrench	1	3.60	3.60
Hole Saw Set	1	12.01	12.01
Lift pump	1	188.5	188.5
Solar system installation	4	2,404	2,404
Extension box	2	2.79	5.58
Spirit level	2	5.20	10.4
Electrical installation	Lump	175	175
5000 L water tank	1	600	600
Green house construction	Lump	655	655
Bags of fish feed	5	37.14	185.7

Table 2. Tools required

Item	Quantity	Unit cost	Total cost
Water quality kits	3	Lump	200.5
Test Strips	2	22.29	45.8
Plastic ruler	2	0.56	1.12
Electronic Scale	2	4.59	9.18
Scoop nets	5	2.6	13

3. Economics

3.1. Business model

The core business model of this small to medium scale aquaponic system with NFT grow beds is the production of fish and vegetables for the local markets.

To make wise investment choices, small-scale farmers and agribusiness owners need information on aquaponics' growth dynamics, nutrient cycling, system management, and profitability. By focusing on a practical, species-specific aquaponic model, this MVP has provided much-needed local evidence that can help farmers make informed decisions. It has also help filled the gap in scientific literature and support the progress of aquaponics as a viable, sustainable farming system in urban and peri-urban settings in Sierra Leone. It also provides significant information for training programs, influence agricultural policies, and contribute to improved food security and livelihoods in the region.

4. Future Improvements

4.1. SWOT analysis of the MVP



Figure 3: SWOT – NUSL LL – NFT Aquaponics

Strengths

- NFT system can simultaneously support fish and okra effectively while maintaining favorable water quality conditions.
- Sustainable and eco-friendly production method combining aquaculture and hydroponics.
- High productivity with favorable fish growth and okra yield demonstrated.
- Efficient nutrient utilization and stable water quality ensuring system reliability.
- Potential for higher economic returns compared to traditional methods.
- Reduced resource use (water, land) and environmental impact.

Weaknesses

- Initial setup costs for aquaponics systems can be high.
- Requires technical knowledge and management skills for system maintenance.
- Limited scalability without proper infrastructure and expertise
- Market acceptance and consumer awareness might vary

Opportunities

- The MVP can significantly contribute to increased local food production and nutrition.
- Potential for government incentives, training programs, and subsidies
- Potential for smallholder farmers and entrepreneurs to generate sustainable income
- Opportunities to optimize system design, species selection, and management practices.
- Encourages innovation in urban and peri-urban agriculture
- Reduces pollution and resource depletion compared to conventional farming

Threats

- Outdoor systems are vulnerable to weather fluctuations and climate change
- Risk of outbreaks affecting fish and plants
- Market price volatility for fish and produce may impact profitability
- Absence of clear policies supporting aquaponics systems and safety standards
- Competition from established traditional farming practices and imports

4.2. Optimization

- Leverage crowdfunding platforms to secure capital for the initial infrastructure investments.
- Pursue collaborations with local enterprises or non-governmental organizations that can offer financial support to resources.
- Develop the system to be modular and scalable, enabling gradual expansion in response to rise in demand.

4.3. Threat mitigation

Mitigating threats in NFT (Nutrient Film Technique) aquaponics entails the identification and management of biological, mechanical, chemical, and environmental hazards that could adversely impact the health of fish, plants, or the overall efficiency of the system.

Fish Diseases and Parasites

Risk: Pathogens (including bacteria, fungi, and parasites) can lead to widespread fish deaths.

Prevention:

- Ensure water quality is optimal (ammonia levels below 0.5 mg/L, nitrite levels below 1 mg/L).
- Isolate new fish for a period of two weeks prior to their introduction.
- Consistently observe fish behavior to detect early indications of stress or illness.
- Incorporate probiotics or immunostimulants into their diet instead of using antibiotics.

Clogged Pipes in NFT Channels

Risk: Inconsistent distribution of nutrients and water → stress on plants.

Prevention:

- Employ filters or screens to catch solids prior to water entering NFT channels.
- Implement regular flushing of the channels.
- Utilize channels with a slight slope (1–3%) for optimal flow.

Chemical Hazards***i. Accumulation of Toxins or pH Issues***

Risk: Ineffective biofiltration results in the buildup of ammonia or nitrites; improper pH levels hinder nutrient absorption.

Prevention:

- Keep pH levels between 6.8 and 7.2 for the best balance.
- Conduct weekly tests for ammonia, nitrites, nitrates, and pH levels.
- Gradually adjust pH using safe buffering agents (calcium carbonate, potassium bicarbonate).

ii. Polluted Inputs

Risk: Utilizing unsafe water, feed, or fertilizers may introduce harmful substances.

Prevention:

- Only use dechlorinated or filtered water.
- Obtain high-quality fish feed.
- Refrain from using chemical pesticides or herbicides close to the system.

Environmental Risks***i. Variations in Temperature***

Risk: Causes distress to fish and plants; impacts nitrification processes.

Prevention:

- Install shading nets or insulation.
- Employ heaters or chillers during extreme temperature conditions.
- Select temperature-resistant species (e.g., tilapia and basil).

ii. Power Failure

Risk: Loss of aeration and circulation → potential suffocation of fish.

Prevention:

- Have backup generators or solar-powered pumps available.
- Utilize battery-operated aerators for emergency assistance.

Operational & Human Risks

i. *Inadequate Management or Oversight*

Risk: Overfeeding, inconsistent maintenance, or slow response to problems.

Prevention:

- Create a standard operating procedure (SOP) and maintenance timetable.
- Train personnel in aquaponics monitoring and sanitation practices.
- Maintain daily logs of water conditions, feed inputs, and harvests.

5. Appendices

5.1. References to experiments

Two undergraduates research have been conducted on the MVP, and one MSc research was conducted.

Undergraduate (Completed and defended successfully)

1. Evaluating the growth performance of the African catfish (*Clarias gariepinus* Burchell 1822) and okra (*abelmoschus esculentus* L) in an indoor NFT aquaponics system.
2. Assessment of the Length-Weight Relationship and Condition Factor of *Clarias gariepinus* raised in indoor Aquaponics system.

Postgraduate – (Completed and defended successfully)

Evaluation of the growth and economic performance of *Clarias gariepinus* and *Abelmoschus esculentus* in an outdoor NFT aquaponic system

6.2. Photographs and additional Documentation



Figure 4: Innovation actors and students operating the NFT system