



Minimum Viable Product Documentation
MVP - Simplified Aquaponics
AGLOBE Living Lab



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1. Overview

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Innovation Actor: Aglobe Development Center and Host (Anjorin) Community

Location: Aglobe Development Center

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1.1. Abstract

The MVP implements a simplified gravity fed aquaponic system with a manual pump, header tanks and gravel substrate beds. A key design element of the system is its capacity to function with minimal or no reliance on electricity. This off-grid operational capability is intended not merely as an emergency contingency but as a standard operating mode, ensuring that the physiological and environmental needs of both fish and plants are consistently met. The system is engineered to maintain these conditions even under maximum load, defined as the point at which the established carrying capacity for fish and plants is fully utilized.

1.2. System design

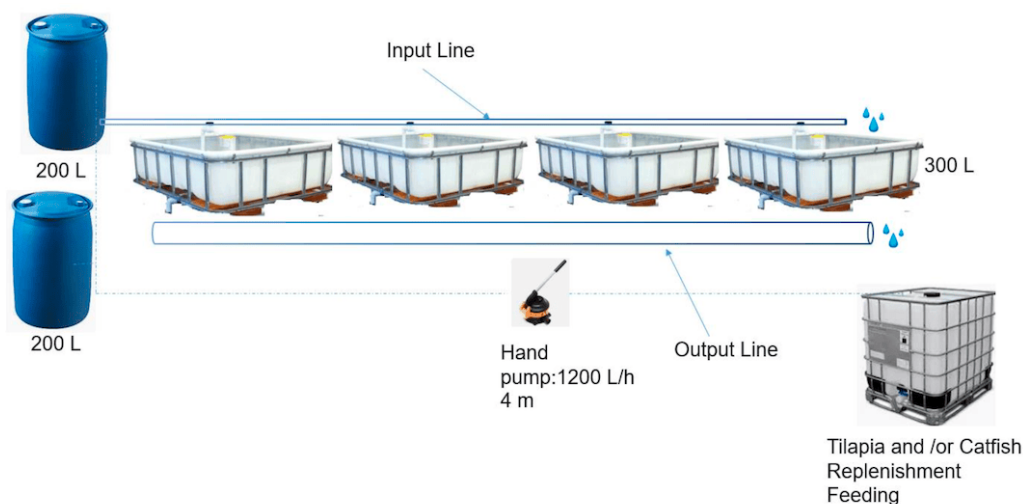


Figure 1: System setup design sketch



Figure 2: Photo of implemented system at ADC, Lagos, Nigeria

1.3. Motivation and challenges addressed

Climate change, resource constraints, and youth disengagement present urgent challenges to African agriculture. This study introduces and evaluates a low-cost, low-energy aquaponics system co-developed by academia, private sector, and NGOs to enhance climate resilience, nutrition, and livelihoods. Designed for off-grid operation, the system integrates African catfish (*Clarias gariepinus*) and Amaranth (*Amaranthus spp.*) within a simplified, gravity-fed configuration requiring minimal technical skills and capital (less than EUR500). Over a 60-day trial, the system maintained optimal water quality (DO ~4 mg/L; pH ~7; NH_4^+ <0.05 mg/L), produced optimal Amaranth (*Amaranthus spp.*) yield, and achieved African catfish (*Clarias Gariepinus*) growth from 20 g to 125 g with 90% survival. Water use was 3 L/day, underscoring efficiency for drought-prone areas. The systems' affordability, scalability, and integration into agricultural education position it as a viable climate-smart innovation for smallholder adoption. Policy integration, local manufacturing, and market linkages could accelerate the role of such agri-innovation in transforming African food systems.

1.4. Feedback process

The development of the prototype was the result of a collaborative effort involving the non-governmental organization Aglobe Development Center (ADC), Nigeria; Aquaponik Manufaktur GmbH; and the University of the Bundeswehr Munich (UniBw M), Germany. Its practical implementation engaged students from the Federal University of Agriculture, Abeokuta (FUNAAB), Nigeria, thereby integrating capacity-building into the project's execution. The initial conceptual design (Figure 1) was prepared by ADC and subsequently shared with UniBw M and Aquaponik Manufaktur GmbH for technical refinement, leveraging their specialized expertise and experience to optimize the system's functionality.

2. Implementation

2.1. MVP Design

Fish Tank Specifications

The system utilizes an Intermediate Bulk Container (IBC) tank as the primary fish tank, providing a maximum capacity of 1,000 liters. In the operational configuration, 800 liters of this capacity are allocated for system functioning, ensuring optimal water volume for maintaining stable aquaculture conditions.

Header Tanks

The system incorporates two header tanks, each with a capacity of 200 liters, designed to sustain water circulation for several hours without active pumping. From these tanks, water is directed through the plant grow-bed filtration system and subsequently returned to the fish tank via gravity flow, thereby ensuring continuous nutrient cycling and reducing reliance on external energy inputs.

Grow Beds

The grow-bed component comprises two Intermediate Bulk Container (IBC) tanks, each modified by removing the top and bottom sections to a height of 30 cm, thereby creating four independent growing units. Collectively, these containers provide an effective cultivation area of approximately 4 m². The beds are filled with a suitable inert medium, such as gravel, which functions as a biofiltration zone. Within this zone, residual organic particles undergo further decomposition, and nitrifying bacteria play a critical role in converting ammonia into nitrate, thereby maintaining water quality essential for plant and fish health.

The simplified aquaponics system is intended to be cultivated with Amaranth (*Amaranthus spp.*) and African catfish (*Clarias gariepinus*). The African catfish possesses a unique combination of physiological traits that make it exceptionally suited for low-intensity, resilient aquaculture. This resilience is rooted in

its evolutionary adaptations to harsh and variable environments. The most significant adaptation is its ability to breathe atmospheric air with a specialized organ at the gills, which functions as a primitive lung, allowing it to survive for extended periods in water with very low dissolved oxygen (DO) concentrations (Onyejiaka & Osuigwe, 2019). While most fish species require continuous aeration to maintain DO levels above a critical threshold, the African catfish can tolerate DO levels as low as 0-3 mg/L without mortality (Environmental, 2012).

2.2. Operations

The system is designed for a maximum stocking density of 8.4 kg/m³ and an average Flow Rate of 1 L/min using a maximum feeding rate of 100 grams per fish per day.

Process water is pumped from the fish tank to the header tanks with a manual pump twice per day at an interval of approximately seven hours.

The water replacement with fresh water was measured to be about three liters per day.

The grow beds are stocked with Amaranth. After 45 days of cultivation the plants reached an average height of 90 cm with approximately 255 leaves per plant.

2.3. Bill of materials

Table 1. Bill of materials

Item	Quantity*	Unit cost €	Total cost €
IBC tanks (incl. Transport)	3	42	126
Blue Barrels (incl. Transport)	2	12	24
Wood (incl. Transport)	1	38	38
Hand Pump	1	38	38
Pipes and Fittings	1	57	57
Blockwork (incl. Labor; optional)	1	50	50
Total			333

3. Economics

3.1. Business model

The systems robustness and affordability place this concept into the realm of smallholder farmers. Multiple grow beds and the fish tank require production space, but the independence from the electricity grid allows this type of system to be an excellent entry point into small scale aquaponic farming, in particular in the peri-urban environment. The hand pump can be easily replaced with an electrical pump, allowing for easy optimization and subsequently up-scaling of the system.

4. Iterative Optimization

4.1. SWOT analysis



Figure 3: SWOT – ADC LL Manual Aquaponics

Strengths

- Low cost for a small commercial setup
- Off grid production
- Good automation potential replacing the hand pump with electrical or solar pump
- Good productivity, water use efficiency and space use efficiency compared to field farming
- Unhindered access to fish tank
- Flow regulators generate constant flow rate from header tanks

Weaknesses

- Labor intensive
- Aquaponics requires knowledge and skills
- Production intensity, stocking density, feed intensity lower than in electrified system

Opportunities

- Growing interest in urban farming
- Contributes to food security
- Upgrades with electrical or solar pump

Threats

- Weather extremes like heavy rains may affect outdoor system
- Market competition from commercial, automated systems
- Regulatory barriers and lack of policy support

4.2. Optimization

The system can relatively easy be upgraded with an electrical pump or solar pump replacing the manual pump, mitigating the high labor intensity of the manual operation.

4.3. Threat mitigation

The outdoor placement leaves the system vulnerable to heavy rainfall. A transparent roof in combination with a fresh water collection tank might alleviate this risk and contribute to rain water collection at the site, further increasing its robustness.

5. Appendices

5.1. Additional Photos and documentation



Figure 4: System in operation with Amaranth crop before harvest

5.2. References

Onyejiaka, A. I., & Osuigwe, D. N. (2019). Swimming in the mud – a short review of environmental parameters for the culture of the African catfish, *Clarias gariepinus*. AACL Bioflux, 12(1), 9-17.

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