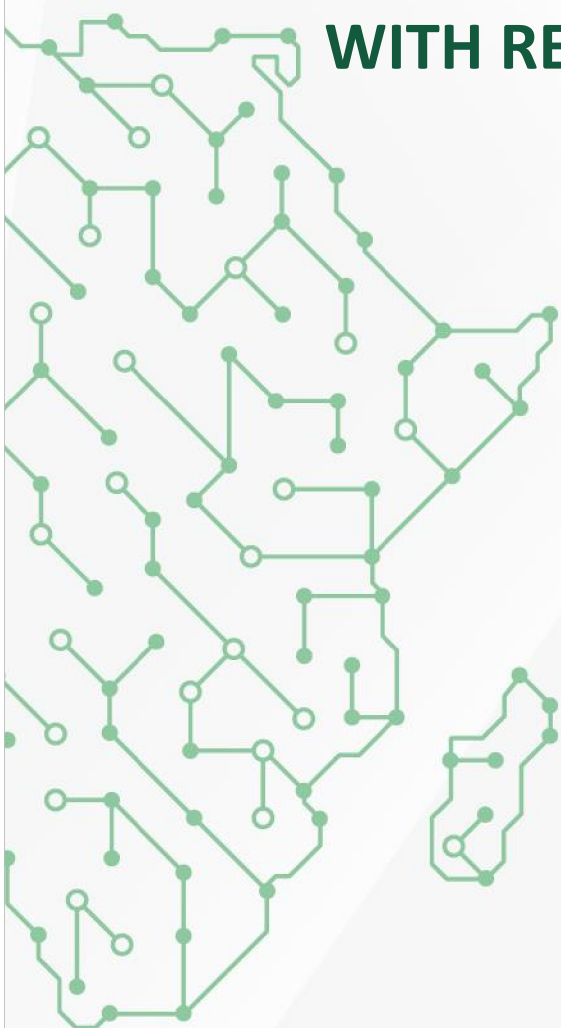




**SIMPLIFIED HYDROPONIC SYSTEM
WITH RECYCLED WATER BOTTLES
MVP-2 KU**



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1. Overview

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Location: Kenyatta University, Nairobi and Kenyatta Market, Kiambu, Nairobi

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1.1. Abstract

Limited access to land, costly fertilizers, and water scarcity constrain vegetable production in urban and peri-urban areas. This MVP introduces a low-cost hydroponic system built from recycled water bottles and plastic containers. A jerrican placed above the setup delivers BSF frass-based liquid fertilizer by gravity through pipes to the plant units. Excess nutrient solution is captured in a collection bucket and recirculated, ensuring closed-loop nutrient and water efficiency. Trials have shown this design effectively supports vegetable growth, offering a sustainable, affordable option for household and small-scale soilless farming using waste-derived organic inputs.

1.2. Photo



Figure 1: KU simplified hydroponic setup



Figure 2 : Kenyatta Market hydroponic test system with jerricans

1.3. Motivation and challenges tackled

Urban food insecurity is exacerbated by high input costs, shrinking farmland, and reliance on chemical fertilizers. Commercial hydroponic systems are too costly for small farmers. This MVP addresses these issues by:

1. Re-using plastic bottles and containers to reduce costs and waste.
2. Using BSF frass fertilizer as an affordable organic nutrient source.
3. Employing a gravity-fed closed-loop system, reducing water and fertilizer loss.
4. Demonstrating a scalable, sustainable model suitable for urban households and schools.

1.4. Feedback process

The Living Lab (LL) research team is working with a farmer from Kenyatta Market (KM) in the Kiambu neighborhood, that is located north of the KU campus, to refine the system's design and assess performance. Interactions include setting up prototypes, monitoring plant growth, and analyzing nutrient efficiency. The Innovation Actor provides input on system assembly, cost feasibility, and practical challenges, while the LL team supplies technical expertise and data analysis. Feedback is exchanged iteratively to improve the design before scaling to farmer-level demonstrations.

2. Implementation

2.1. MVP Design

The MVP is modelled after the Garrafas PET design that was introduced to the project by the UniBo (P9) project partner. The system utilizes waste bottles that are assembled in a row and cut open and filled with substrate as low cost grow beds.

These are the components of the setup:

1. Reservoir (Main Tank)

The MVP uses a 20–30 L jerrican fitted with a tap/valve to store the nutrient solution. It is raised on a stand so water can flow by gravity. This removes the need for an electric pump, making the system very cheap and easy to maintain.

2. Distribution System

From the jerrican, small plastic tubes carry the nutrient solution to each plant container. Gravity ensures a slow and even flow, so all plants get enough water and nutrients. The design is simple, low-cost, and easy to repair.

3. Growing Units

The plants grow in recycled plastic water bottles that are cut open and filled with pumice or gravel. These materials support the roots, allow good airflow, and prevent waterlogging. Using recycled bottles makes the system climate-friendly and very affordable.

4. Drainage and Collection System

After passing through the plant bottles, excess nutrient solution drains into PVC drainage pipes and finally into a collection bucket at the bottom. This prevents wastage and keeps the system neat and clean.

5. Recirculation

The collected nutrient solution in the bottom bucket is reused. The user simply pours it back into the jerrican to start the cycle again. This saves water and reduces the cost of nutrients.

2.2 Operation (Step-by-Step)

Step 1: Prepare the Nutrient Solution

Mix water with nutrients in the jerrican. Ensure the tap/valve is working.

Step 2: Start the System

Open the tap slightly to allow a slow, steady flow. Gravity pushes the nutrient solution through the pipes.

Step 3: Nutrient Distribution

The solution flows through the plastic pipes and drips into each plant bottle. The pumice/gravel holds the plant upright and provides support.

Step 4: Collection

Excess water drains through small holes in the bottles. It flows into the drainage pipe and down into the bottom bucket.

Step 5: Recirculation

When the bottom bucket fills up, pour the solution back into the reservoir. Refill the nutrient levels if needed.

OPERATION IMPROVEMENT STEPS

1. Monitor Flow Rate

If the flow is too fast, close the tap slightly. If too slow, open a bit more.

2. Clean Pipes Weekly

Remove algae or blockages to keep the water flowing smoothly.

3. Replace or Wash Growing Media

After every 3–6 months, wash the pumice/gravel to remove salt buildup.

4. Check Nutrient Strength

Add nutrients every 3–5 days depending on plant type.

5. Lift the Stand if Pressure Reduces

Raising the jerrican by a few centimetres improves gravity flow.

2.3. Bill of materials and required tools

Table 1: Bill of materials

Item	Quantity
Recycled plastic water bottles (1.5–2L)	30
Plastic containers (support structure)	5
Jerrican (20L)	1
Plastic pipes	5 m
Cotton/mesh filters (for outlet)	1
Collection bucket (20L)	1
Pumice/gravel	30 kg
BSF frass fertilizer	10 litres
Vegetable seedlings (Amaranth, Kale, Cowpea)	

Table 2: Tools required

Tool	Quantity
Knife/scissors (cutting bottles)	1
Hand drill / nail (for pipe holes)	1
Measuring jug	1
Bucket (fertilizer mixing)	1
Gloves & safety gear	1
Collection bucket (20L)	6

3. Economics

3.1. Business model

This MVP opens the opportunity for three different kinds of business:

1. **Vegetable Production and Sales:** Growing and selling fresh vegetables using the system for steady income.
2. **Kit Production and Sales:** Manufacturing and selling low-cost hydroponic kits to households, farmers, and schools.

3. Installation & Maintenance Services: Providing installation, training, and after-sales support as an optional consulting service.

Key Partners - Hardware shops (pipes, taps, jerricans) - Recycled bottle collectors - Pumice/gravel suppliers - NGOs & climate-smart programs - Schools & youth groups - Transport services - Courty governments	Key Activities - Grow and sell vegetables - Produce hydroponic kits - Install kits (consulting) - Maintenance & after-sales support - Training customers	Value Proposition For vegetables fresh, clean, pesticide-free vegetables Install kits affordable, water-saving space-efficient hydroponic kit Feedback loops product improvement	Customer Segments Vegetables - Fresh, clean, pesticide-free vegetables Kit buyers - Affordable, water-saving, space-efficient hydroponic kit made from recycled materials Installation/Maintenance - Busy urban clients, institutions and NGOs
Key Resources - Technical staff - Jerricans, pipes, recycled bottles - Pumice/gravel	Cost Structure Raw materials (pipes, bottles, jerricans) Puremrot	Customer Segments Vegetables households, farmers, youth groups, schools Kit partes social medium, Facebook, TikTok	Revenue Streams 1. Vegetable Sales, continuous supply to homes, hotels, markets, schools 2. Kit Sales, small, medium, large hydroponic kits, custom systems for NGOs/schools 3. Installation & Maintenance Services installation fees, training fees, monthly maintenance contracts

Figure 3 : Business Model Canvas for the simplified hydroponic system

4. Future improvements

4.1. SWOT analysis

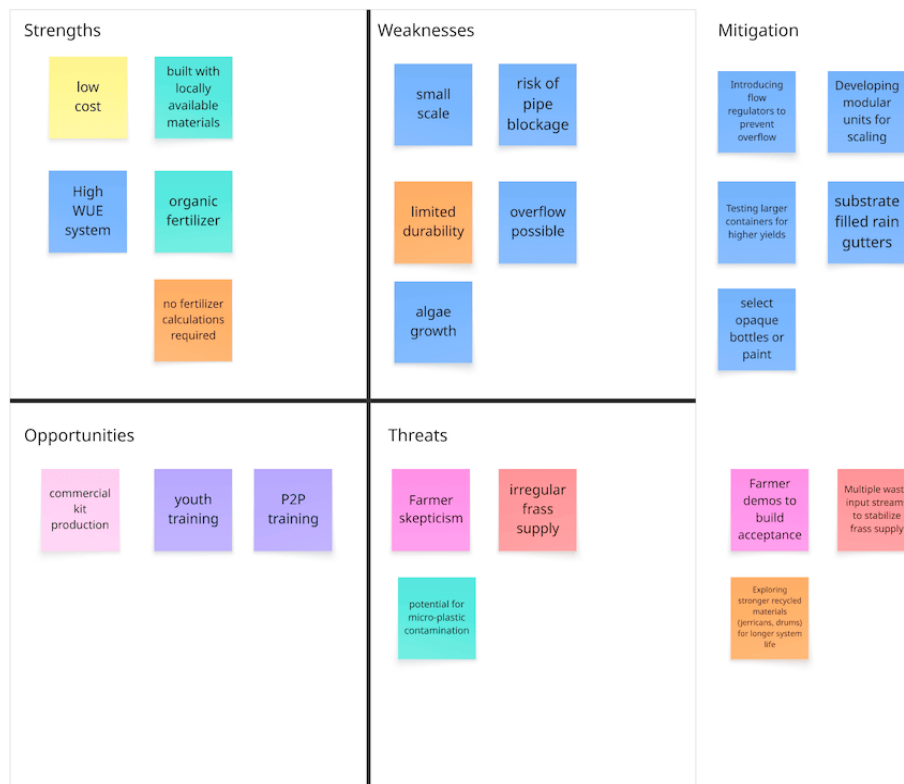


Figure 4: SWOT - KU LL -simplified hydroponic system (Garrafas) PET with liquid fertilizer from BSF frass

- Strengths: Low cost, recyclable, water-efficient, organic fertilizer, no fertilizer calculation
- Weaknesses: Small-scale, risk of pipe blockages, limited durability, overflows possible, algae growth
- Opportunities: Urban food security, youth training, commercial kit production.
- Threats: Farmer skepticism, irregular frass supply, plastic bottle fragility. Microplastic?

4.2. Optimization

- Introducing flow regulators to prevent overflow.
- Testing larger containers for higher yields.
- Develop modular units for scaling.
- Experiment with substrate filled rails. See photo below.

4.3. Threat mitigation

- Farmer demos to build acceptance.
- Multiple waste input streams to stabilize frass supply.
- Explore stronger recycled materials (jerricans, drums) for longer system life.

5. Appendices

5.1. Additional Notes

This MVP was showcased at the Nairobi International Trade Fair 2024 as well as 2025 where it attracted attention from farmers, students, and policymakers as a low-cost and practical innovation for urban and peri-urban food production. Feedback from the exhibition demonstrated strong interest in the system's affordability, use of recycled plastics, and organic frass fertilizer. KU LL scooped position one on both occasions with other three project on research and development.

5.2. Additional Photographs/Documentation



Figure 5: Garrafas PET system with steel rack



Figure 6: Garrafas PET demonstrator at the Nairobi International Trade Fair 2024



Figure 9: Onboarded farmer with a modified hydroponic near KM