



Promoting Knowledge Sharing Culture

Unlocking the potential of aquaponics in Uganda



Presenter

Cassius Aruho, PhD

Principle Research Officer - ARDC Kajjansi



Facilitator

Constantine Chobet Ondhoro

Aquaculture Scientist - BugiZARDI



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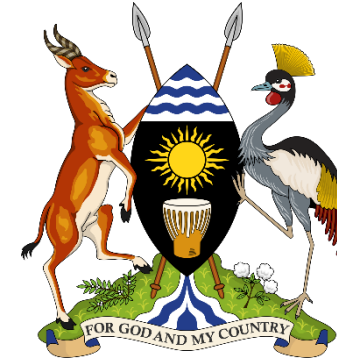
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Un locking Aquaculture Potential in Uganda

Maximizing efficiency and sustainability of aquaponic systems

National Agricultural Research Organisation (NARO)

Introduction: Aquaculture production and consumption patterns in EA

- 75% of East Africans regularly consume fish, 30% of whom consume it as their main source of protein
- Actual consumption of fish in East Africa is roughly 1,300,000MT according to the FAO

Country	Aquaculture production (2021) MT	Estimated farm value @US\$2.7 per Kg
Uganda	138 558	374,481,081.1
United Republic of Tanzania	106 482	287,789,189.2
Kenya	63 355	171,229,729.7
Rwanda	10 313	27,872,973.0

Source: FAO Fishery and Aquaculture Statistics. Global aquaculture production 1950-2021 (FishStatJ)

- Per capita consumption in East Africa is relatively low by global standards (averaging 7.5kg)
- Rwanda's per capita fish consumption = 2.3 kg
- Kenya =4.7 kg per person per year
- Tanzania = 8 kg per person per year
- Uganda = 10 kg per person per year

What are the technology-based systems for Aquaculture

- Aquaculture systems range from very extensive, through semi-intensive and highly intensive to hyper-intensive.
- The progressive staging reflects the increasing level of use of technology in Aquaculture
- That is from non supplementary feeding in extensive systems to highly intensive Automated systems with intensive feed supplementation
- Aquaculture based Technologies focus on use of improved technology/innovations to increase production and productivity.
- The use of automated feeding systems, advanced monitoring and control systems, and the use of renewable energy sources such as solar and wind power, recycled nutrients are some of examples .

Various Aquaculture systems

- ❖ Land-based systems (rainfed ponds, irrigated or flow-through systems, tanks and raceways).
- ❖ Recycling systems (high control enclosed systems, more open pond based recirculation).
- ❖ Water-based systems (cages and pens, inshore/offshore).
- ❖ Integrated farming systems (e.g. livestock-fish, agriculture and fish dual use aquaculture and irrigation ponds)
- ❖ *The level of technology being commensurate with the level of operation*

Ponds



Aquaculture : Farming of aquatic organisms with some form of intervention in the rearing process to enhance production plus ownership

Tanks



Tanks in Uganda

Indoor systems



Courtesy : Sorgeloos, 2009

Cages





Integrated fish/crop/animal farming Strategies

Aim: Increase the productivity of water, land and associated resources while contributing to increased food fish production.

Basically the integrated fish farming is of two types

a) Agri-based fish farming-Paddy – cum-fish culture; Horticulture-cum-fish farming

b) Live-stock fish farming(Poultry-cum-fish farming; Duck-cum-fish culture; Pig-cum – Fish culture; Rabbit-fish integration



Integrated fish and poultry farming



Integrated fish and rice farming



Integrated crop – fish farming systems



E,g. Fish -Rice demonstration at Kajjansi ARDC



Aquaculture-vegetable farming using effluent water from ponds

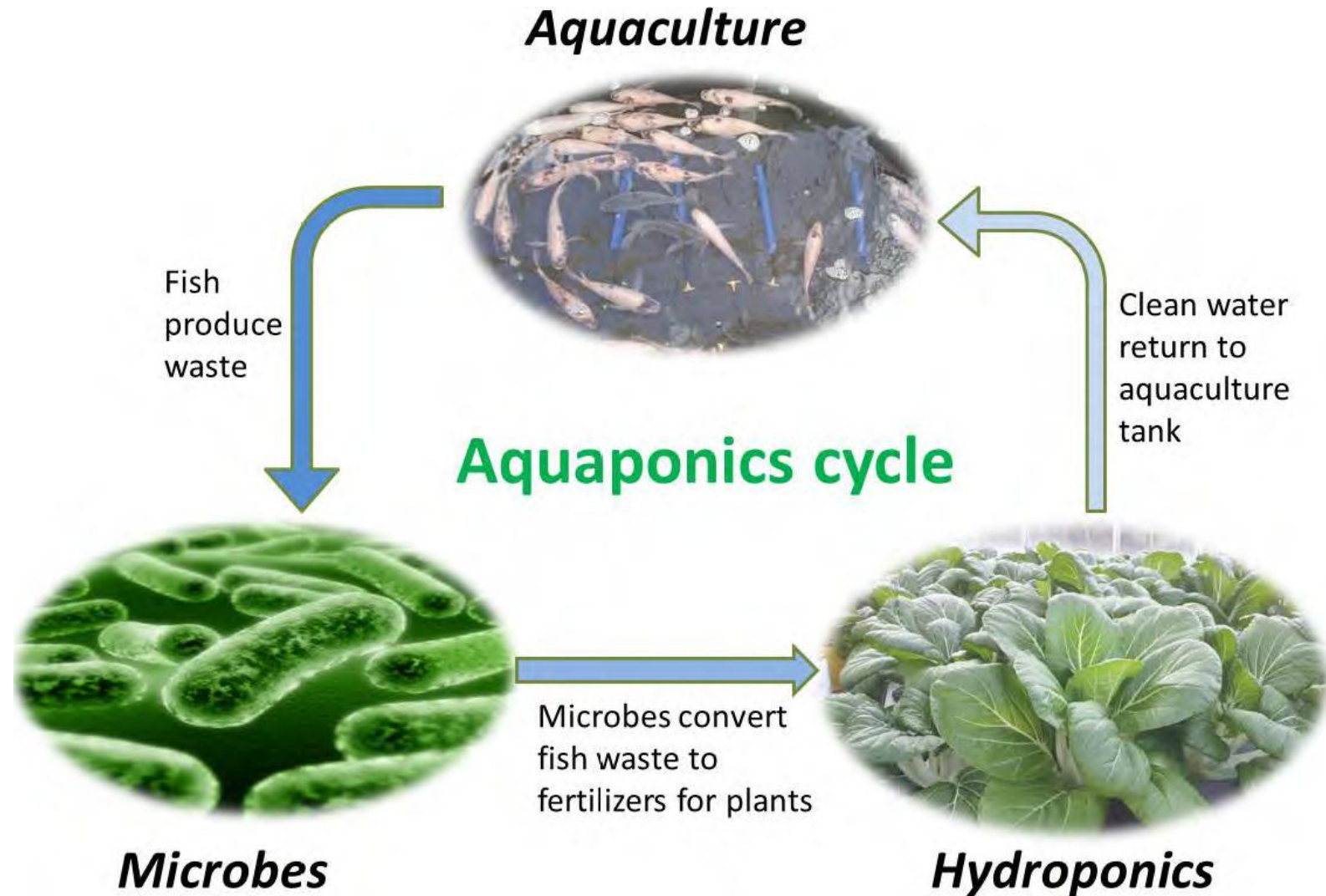
- In this approach, fish pond water is utilized to water vegetables such as onions, tomatoes, and cabbage, hence reducing the farmer's need to buy chemical fertilizers





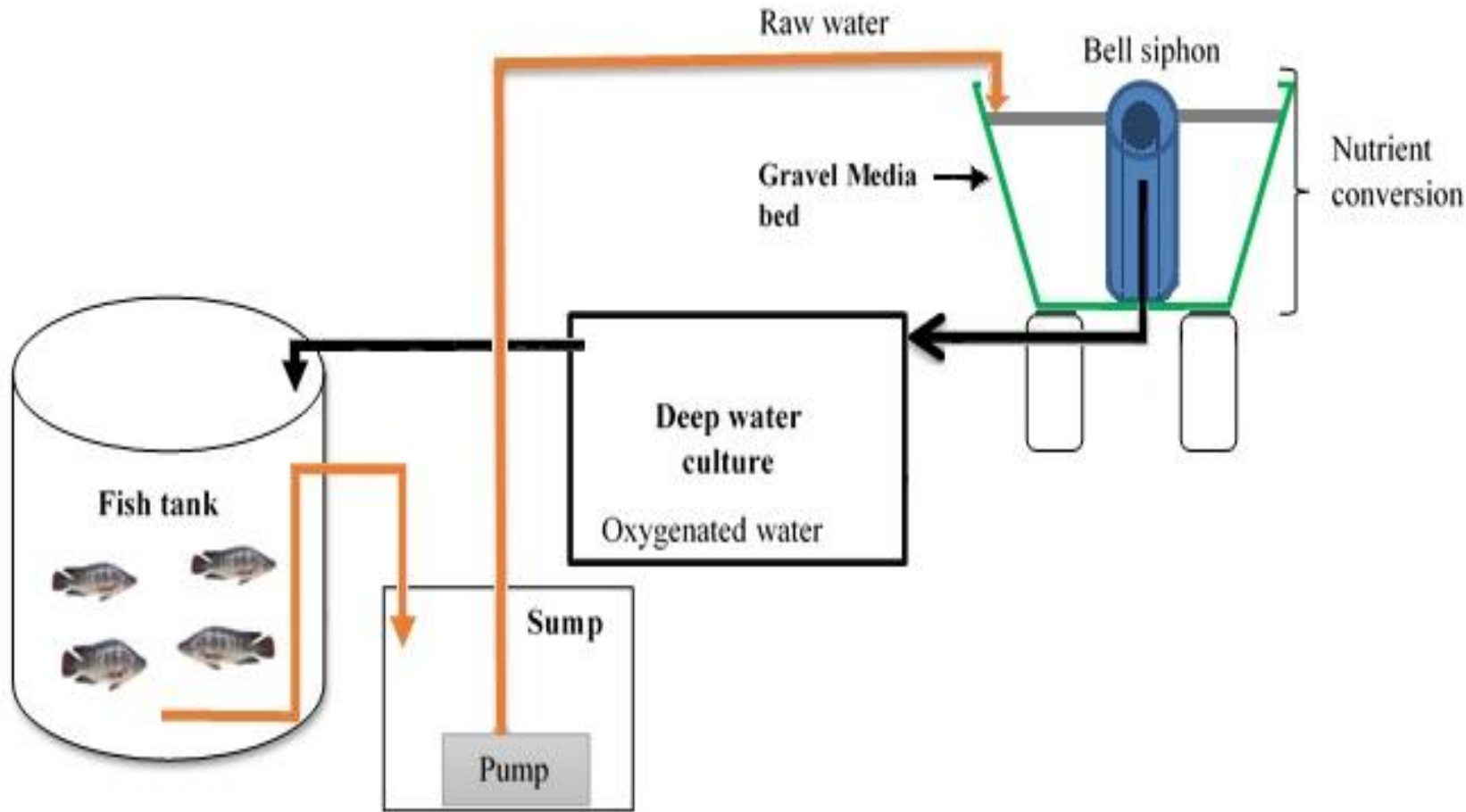
Aquaponics

What is the aquaponics? The Aquaponics cycle



Description of the microbial communities in aquaponics is vital because it increases our understanding of the system's microbial ecology but also provides a basis for managing such communities so as to enhance their function and reliability.

The Principle of aquaponics



The aquaponics involves systems recirculate nutrient-rich water from fish tanks through vegetable beds, where plants absorb the nutrients, before the water—filtered by plants—is returned to the tanks. The system also explores the use of renewable solar energy to enhance sustainability.



Aquaponics types based on on the type of grow bed



1. Deep water/Raft culture

Where plants are supported in rafts that float on nutrient-rich water, with their roots submerged and oxygenated.

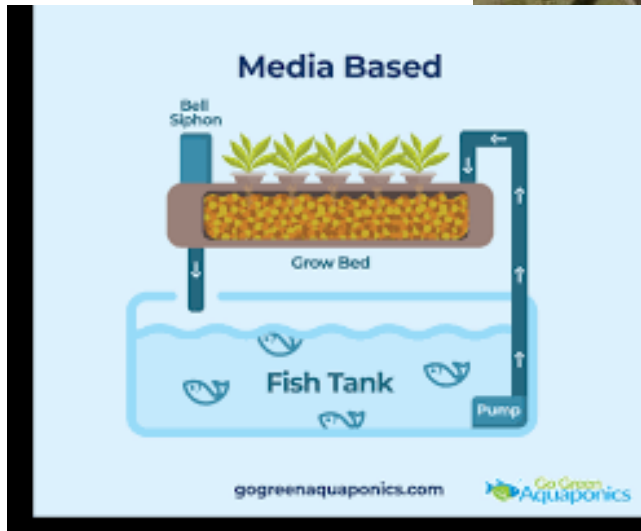
Plants with small root system; e.g. *Lettuce*, *Mint*, *Basil*, *Kale*, *Parsley*, *Rocket*





2) Nutrient film technique

Comprises an active hydroponic system that uses pumps to circulate a thin film of nutrient solution through shallow channels, where plant roots can dip to receive nutrients e.g. the lettuce



3) Media-based aquaponics

This is where plants are grown in a bed filled with a solid medium, like gravel or clay pebbles, that supports their roots and also acts as a biofilter

Media examples of -Tomatoes, -Lemon grass, -Spinach, -Beans, -Peas



Variations in designs of the smallholder systems of aquaponics



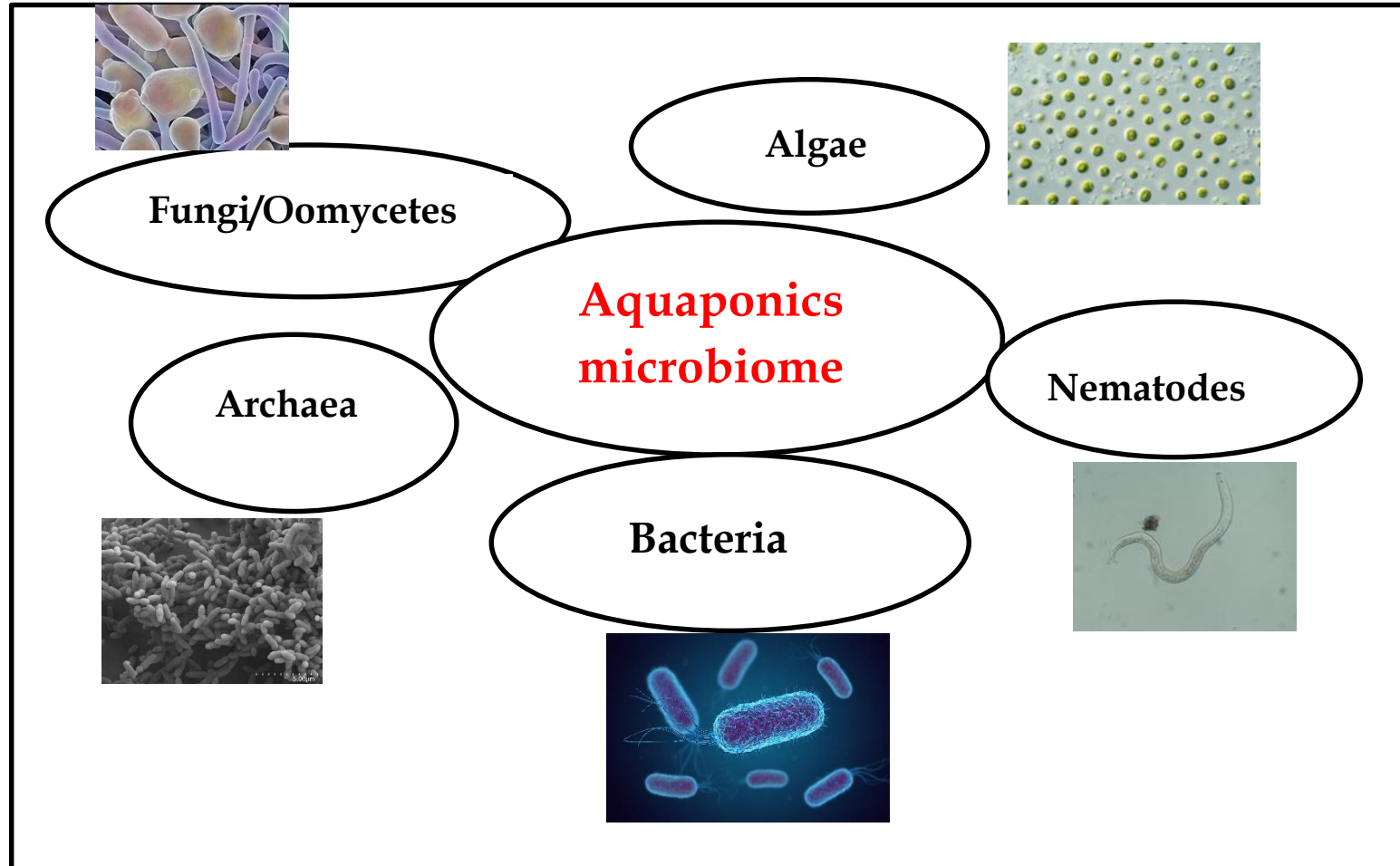


Variations of the smallholder systems of aquaponics



Variants of aquaponics systems owned by farmers in Uganda

Major microorganisms in aquaponics



Non- beneficial

Cause plant and fish diseases, Affect water quality, Compete for nutrients

Beneficial microorganisms

Growth and health, Immune response, Organic matter mineralisation, Protection against pathogens, Nutrient bioavailability, Tolerance to abiotic stress



Biofilter establishment

Biofilter establishment or cycling, a process of building bacterial ecosystems during the setup of an aquaponics system

Cycling with fish:

Takes approximately 4 to 6 weeks for sufficient bacterial populations to develop

Fishless cycling: The better way
Requires less time, i.e., ± 3 weeks compared to the fish cycling method

Liquid ammonia, Ammonium chloride, Ammonium nitrite, organic liquid fertilizers (SeaGro, SeaBrix)



Why bacteria?

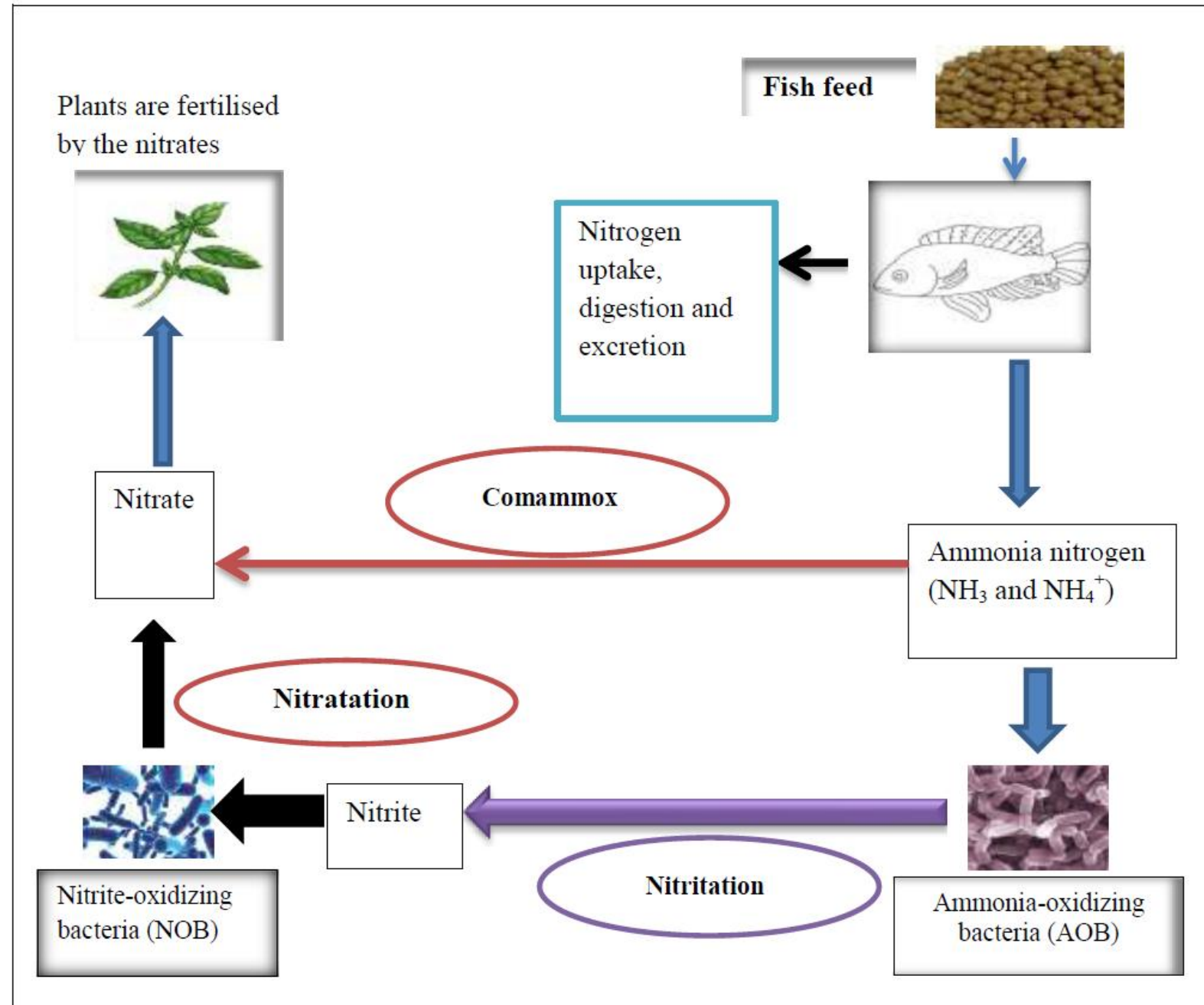
Bacteria are found in almost every compartment of an aquaponic system.

Nitrifying bacteria

Nitrification plays a vital role in regulating the availability of nitrogen in aquaponic systems. This process is conducted by three different groups of bacteria.

Heterotrophic bacteria

Important during organic matter decomposition and mineralisation.





Current status of Aquaponics in EA

- Systems of varying sizes;
- 25,000 small back yard units in EA; over 10,000 in Uganda
- Estimated 300 Medium systems ; over 100 units in Uganda
- Estimated production is hard to come by –no clear records (requiring a survey)
- Some are luxurious or ornamental in urban areas



Why Aquaponics system; Benefits of Aquaponics

- ❖ Produces at least 10 times more crops in the same amount of space as traditional agriculture.
- ❖ Improve nutrient retention efficiency.
- ❖ Reduce water usage.
- ❖ No wastewater discharge to the environment-ecologically friendly – no harm to the environment
- ❖ Diversity of crops farmed in the same space
- ❖ Sustainable for various sizes and budgets
- ❖ Adaptability



Challenges of Aquaponics system

- There are four key issues identified as challenges
 1. Adopting and customizing the highly specialized innovations to our local context
 2. Improving the many small micro systems and make them profitable
 3. Absence of an agroecology decision support tool to guide in assessing usage of the system to respond to emerging climatic changes and responding to social economic benefit (incl food security)
 4. Expertise knowledge



Other related challenges of Aquaponics system

- Availability and cost of inputs (seedlings free of diseases, quality fish seedlings)
- Managing water quality for many is still quite difficult
- Socio-Cultural attributes –smell of fish, cant eat foods raised by the fish fecal droppings
- Aquaponics being labor-intensive – for e.g. change the water in each tank after several 10 days to manage the ammonia in the fish tank
- Social inequalities such as gender discrimination in adoption of such technologies



Overcoming challenges-optimizing the aquaponics systems

- Optimizing systems that can be easily adaptable & Profitable & responsive to Environmental/climate resilience

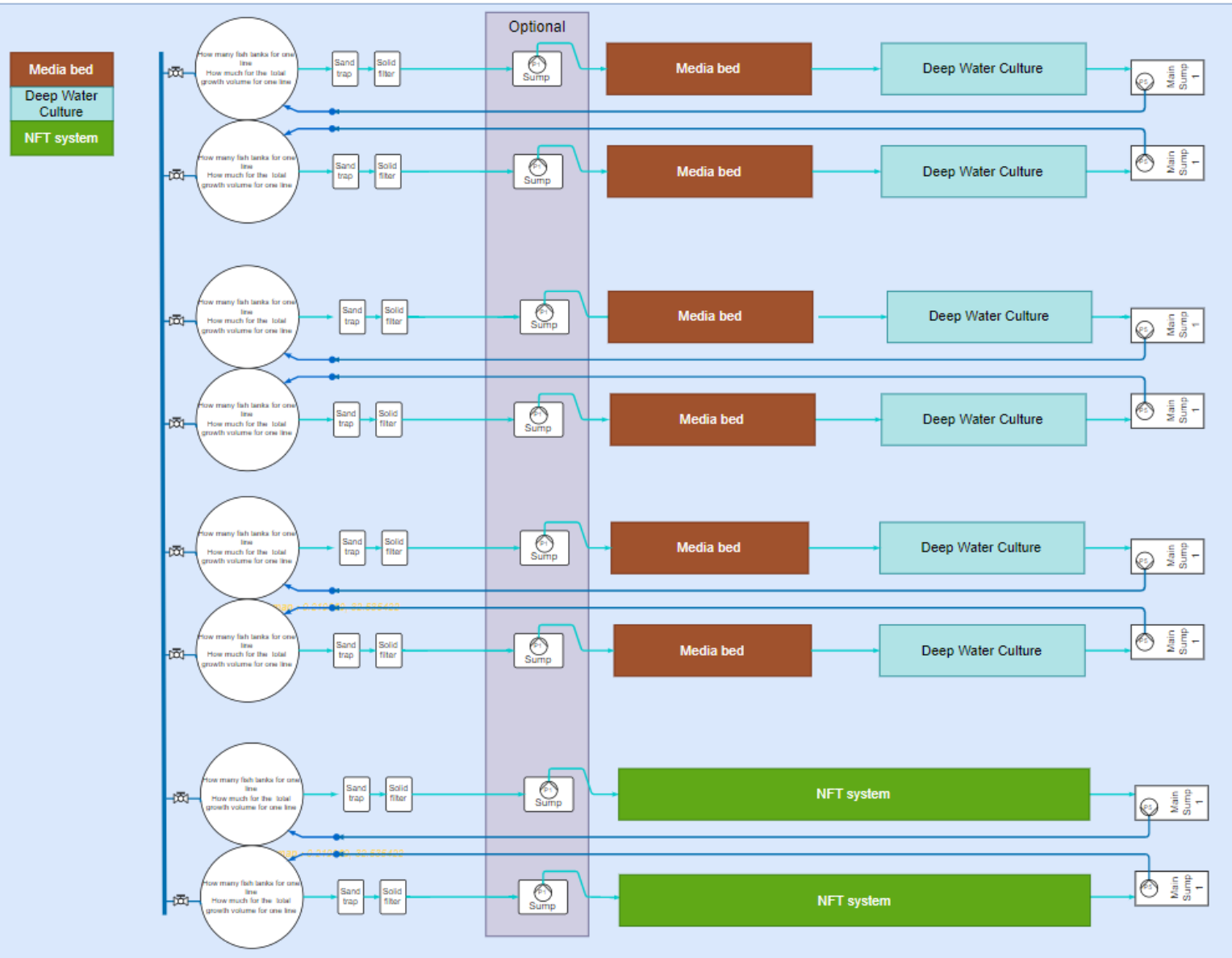
Potentials of Agroecological practices in east Africa with a focus on Circular water-energy-nutrient systems



**PrAEctiCe brings together 16 partners from 9 countries in Europe and Africa led by Hochschule Karlsruhe (HKA) one of the largest universities in applied sciences in the state of Baden-Württemberg.
Implemented in *Kenya Tanzania and Uganda***



The designs of Aquaponics ARDC



- An aquaponic setup that includes media-based culture (MBC), nutrient film technique (NFT), and deep water culture (DWC) was designed and established at Kajjansi
- 1 NFT system
- 6 combined systems (Media bed + Deep water culture)

Each AP consisted of a 1000 L fish tank, two sedimentation tanks each with 200 L, a 500 L flood-and-drain gravel media bed, and a 1500 L deep-water hydroponic culture unit

Construction of the system

- Started in November 2023 and was completed in July 2024 at ARDC Kajjansi

Stage 1: Site clearance



Construction of the system



Fabrication, fixing of structural horizontal steel frames and the top, installation of internal structures

Construction of the Living Lab 2



Figure: completed installation of the aquaponics system

Stabilisation Phase of the aquaponics system



Installed with water quality monitoring and solar systems

Stabilisation Phase of the aquaponics system-testing and optimisation





Operational phase-data collection

- Several experiments have been conducted in the aquaponics systems
- They include:
 - i) Determining growth performance of fish in the aquaponics systems
 - ii) Evaluating the performance of lettuce in the NFT system
 - iii) Comparing performance of lettuce in DWC using nutrient rich water from African catfish and Nile tilapia species
 - iv) Comparing performance of lettuce in Media bed using nutrient rich water from African catfish and Nile tilapia tanks
 - v) Evaluating performance of potted tomatoes with nutrient rich water (effluent) from NFT, the African catfish and Nile tilapia tanks
 - vi) Tested and used organic herbicides (composed of red pepper, Leon, milk, and neem) on the infested plants as a treatment for the pests and diseases within the green hours



Operational phase-data collection

Regular management and maintenance (activities)



Figure: Planting the lettuce in the Deep water Culture



Figure: Planting lettuce in NFT



Figure: Planting the tomatoes under pots



Operational phase-data collection

Regular management and maintenance (activities)



Figure: growing plants; tomatoes in MB, Lettuce in NFT and in DWC



Figure: Potted tomatoes and Kale; ripe tomatoes in MB, mature Lettuce ready for harvest in NFT



Operational phase-data collection

Regular management and maintenance (activities)



Figure: Sampling of fish and plants in aquaponics



Operational phase-data collection

Regular management and maintenance (activities)



Harvesting tomatoes from
the potted plants



Operational phase-data collection

Regular maintenance of equipment



Figure: Repair and replacement of the water pumps is part of the maintenance



Training and dissemination of Information

- ❖ Information has been consolidated in brochures and reports as well
- ❖ Students from various schools visited the facilitate and provided with basic awareness of aquaponics technology and practices
- ❖ 20 internship students have been trained practically on the technology and best management practices in the aquaponics
- ❖ An open day has been undertaken to create awareness and promote the technology of aquaponics in Uganda; conducted at ARDC in June 2029 and over 200 participants were trained



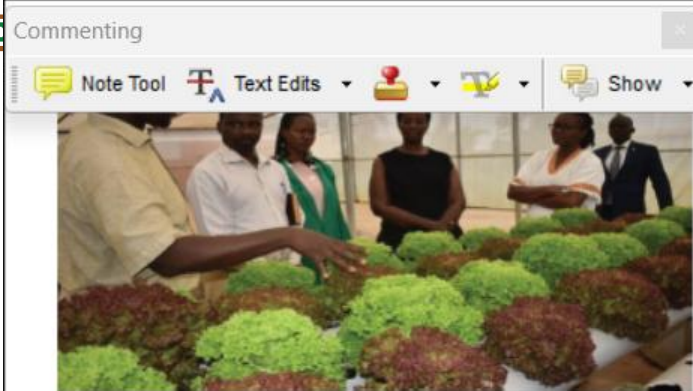


Figure 5: Lettuce performance in NFT at ARDC-Kajjansi



Figure 6: Potted Kale and tomatoes inside the green house at ARDC



Plants grown in the aquaponics

The aquaponics system at the ARDC-Kajjansi has been used to test and grow vegetables presented in table 1 using **DWC, MBC, NFT and pots**. **Figure 5, 6, and 7** show vegetables grown to harvest time.

Fish species grown in the Aquaponics

Nile tilapia and African catfish have been successfully grown at the Aquaculture Research and Development Center (ARDC)

- i) African catfish (*Clarias gariepinus*) (Figure 8), Growing up to 200g in five (05) months
- ii) Nile Tilapia (*Oreochromis niloticus*) (Figure 9), Growing up to 250 in five (05) months



Figure 8: African fish



Figure 9: Nile Tilapia

Table 1: Various plants grown in the aquaponics system

Sn	DWC	MBC	NFT	Pots
1	Lettuce	Tomatoes	Lettuce	Tomatoes
2	Mint	Lemon grass	Kale	Kale
3	Kale	Spinach	Strawberry	Spinach
4	Basil	Pepper		Pepper
5	Parsley			Scarlet
6	Rocket	Peas		



Potentials of Agroecological practices in East Africa: Unlocking Uganda's aquaponics



Aquaponics at the National Fisheries Resources Research Institute at Kajjansi

**NATIONAL FISHERIES RESOURCES
RESEARCH INSTITUTE
AQUACULTURE RESEARCH AND
DEVELOPMENT CENTRE, KAJJANSI
P.O Box 530, Kampala**

Training and dissemination of Information

Introduction

Aquaponics, a combination of fish farming and soilless plant cultivation is a farming technology that maximizes use of on-farm organic inputs for optimum productivity through recirculation of nutrient rich water in a closed system (Figure 1). The practice considers optimizing limited space and efficient use of nutrient rich water as one of the climate resilient transformative solutions for sustainable food production in a country. Aquaponics is one of the integrated aqua-agriculture technologies that is designed to minimize impact of climate change effects on farm and ensure production potential of agro ecologically produced commodities.

Components and types of aquaponics

Aquaponics has two key components of the system.

- The fish tanks (holding fish that produce nutrients-faecal & uneaten feeds)
- The plant culture system (where plants are grown)

There are three key types of the aquaponics systems

- Deep-water Culture (DWC) where plants are supported in rafts that float on nutrient-rich water, with their roots submerged and oxygenated (Figure 2)
- Media bed culture (MBC) where plants are grown in a bed filled with a solid medium, like gravel or clay pebbles, that supports their roots and also acts as a bio-filter (Figure 3)
- The Nutrient Film Technology (NFT) comprises of an active hydroponic system that uses pumps to circulate a nutrient rich water through channels, where plant roots dip to receive nutrients (Figure 4)

These systems integrate the use of nutrients generated from the fish with water circulation using Energy from either solar or hydropower.

Note: The aquaponics systems may vary in designs and



Figure 1: Re-cycling of nutrient rich water in aquaponics



Figure 2: Deep-water Culture Systems at ARDC Kajjansi



Figure 3: Media Bed Culture system at ARDC Kajjansi



Figure 4: Nutrient Film Technology system at ARDC

Training and dissemination of Information

Conclusions:

1. The African catfish has a better survival rate in the aquaponics systems compared to Nile Tilapia
2. Nile tilapia growth performance was better than that of the African catfish.
3. Plants grown using tilapia fish effluents grow faster and give a better yield at harvest
4. Success in aquaponics depends on providing better management practices like using quality feed, and maintaining optimal water quality ranges. This ensures nutrient availability for crops while ensuring good fish health.

Recommendations

- 1) Use of Nile tilapia enhances plant yields in aquaponics in a shorter period compared to
- 2) Conduct further studies to characterize and identify the beneficial microbiomes existing in each production system
- 3) More experiments shall be conducted to assess performance of other important plants suitable for aquaponics .



FAO Regional team visiting the aquaponics system



Deep-water culture with green and red lettuce sp

Cassius Aruho, Nasser Kasozi, Barry Kamira, Idd Ramathani, Henry Katumba, Evelyn Ajore, Godfrey Byaruhanga, Lydia Nakasiga, Papius Tibihika, Win-



Determining growth performance and yields for fish, tomatoes (Anja F1) and lettuce in aquaponics



Anja F1 tomatoes growing in the media bed culture

National Agriculture Research Organization
(NARO)

National Fisheries Resources Research Institute
(NaFIRRI)

Aquaculture Research and Development Center
Kajjansi (ARDC)



Training and dissemination of Information

Introduction

Aquaponics, a combination of fish farming and soil-less plant cultivation is a farming technology that maximizes use of on-farm organic inputs for optimize productivity.

The practice considers optimizing limited space and efficient use of water as a transformative solution for sustainable food production in a country. The technology minimizes impact of climate change effects on farm and ensure production potential of agro ecologically produced commodities

The need to increase sustainable food production and match the food security demands under climate change impacts calls for investigative research to develop a system that encompass the circular water-energy-nutrient utilization in plant production focusing on integrated aqua-agriculture (e.g. aquaponics).

Improving growth performance of tomatoes and lettuce in aquaponics

Growth performance of tomatoes and lettuce were determined in the Media bed culture (MBC) fig 1 and Deep-water Culture (DWC) fig 2, of the aquaponics system. The system utilized nutrients generated from the Tilapia and African catfish stocked separately in the circular tanks, each in triplicates.

The tomatoes and lettuce in the Media bed and deep water culture system drew nutrients from water flowing through the system by gravity before it was



Fig 1. Tomatoes in MBC



Fig. 2. Lettuce in the DWC

pumped back into the fish tanks for use by fish.

Fish stocking, feeding strategies, and plant growth

Three fish tanks (1000M³ each) were stocked with 200 fingerlings of the African catfish each. Another three tanks were stocked with 200 fingerlings of Nile tilapia each. Fish were fed to satiation three times a day.

There were six lines, each with a fish tank, two (02) MBC and a DWC tank. Three lines were supplied with nutrient rich water from the tilapia tanks, the other lines by the African catfish. These lines were independent of each other. Nine (09) tomato seedlings were planted in each of the MBCs and 50 Lettuce seedlings in each of the DWC Tanks.

Sampling and harvesting

Crop sampling was done every fortnight (14 days). The collected data included that of plant head weight, height, leaf size, diameter, area, number of fruits grown and weight of the fruits.

Lettuce harvest was done between 28 and 35 days, and after 65 days for the tomatoes.

Fish sampling was done monthly to collect data on fish weight, Length and Food Conversion Ratios (FCR)

Findings

Plant optimal growth and average growth rates

Results revealed that crops using effluents' from the tilapia treatment significantly ($p < 0.05$) performed better than crops supplied with effluent from African catfish tanks (Table 1).

Table 1. showing growth performance in plants

	Cycle 1		Cycle 2	
	Catfish effluents	Tilapia effluents	Catfish effluents	Tilapia effluents
1 Head weights at harvest (g)	18,929.80	29,990.00	19,546.50	20,850.80
2 Ave plant weight (g)	175.31	190.76	133.88	134.52
3 Growth Rates (g/day)	2.619±0.74	4.041±0.55	0.433±0.128	0.411±0.05

The African catfish showed a higher survival rate than Tilapia. The FCRs were 1:1.28 and 1:2.2 for catfish and tilapia respectively.

Table 2. Growth performance of catfish and tilapia

Parameter	Catfish	Tilapia
Daily Weight gain (g/day)	0.486 ± 0.01	0.675 ± 0.058
Specific Growth rate (%/day)	2.137 ± 1.25	3.069 ± 0.890
Survival rate (%)	95.83 ± 1.89	82.43 ± 6.05
Feed conversion ratios	1.21 ± 0.369	2.21 ± 1.04

Water Quality and Effluent dynamics

Water quality Parameters were kept within the optimum ranges (Table 3).

Table 3 Shows the optimal and observed water chemis-

Parameters	Optimal Ranges	Catfish Tanks	Tilapia Tanks
pH	6.5 - 7.0	6.45	6.13
Water temperature	17 - 30 °C	25.10	25.23
Dissolved Oxygen	>5 mg/L	5.37	5.6
TDS	<1000 mg/L	580	680
Nitrates	5 - 150 ppm	0.182	0.169
TAN	<2 mg/L	0.785	0.758
Electro-Conductivity	100-2000 µS/cm	114	98.33
Salinity	0-2 ppm	0.44	0.52
Air temperature	18-30°C	28	28
Nitrite	<1 mg/L	0.014	0.018
Free ammonia	<1 mg/L	0.00	0.00

try



Training and dissemination of Information





Moving forward

- Capacity building of stakeholders
- Technical training for students
- Creating awareness to reduce the gender discrimination /other social –cultural perspectives
- Farmer-to-farmer teaching is another key ingredient, along with community strategies to address social inequalities such as gender discrimination
- Work with communities to support modifications or customisation of the system
- Open days for participants
- Share Knowledge



Why promote aquaponics

- Backyard farming for nutritionally balance foods for families/house holds with limited space (M3-4 cycles of green foods-large fruiting plants)-paper, lettuce, tomatoes tomatoes-150 fish in 1000l plastic tanks)
- Introduction of **solar water pumps** to reduce on the water exchange process
- One of the key benefits of aquaponics is its ability to generate sustainable income for farmers
- Employment of youth and women
- Market for all the high value crops and the produced fish



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