Backyard Fish Farming

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To my lovely daughters and beautiful wife, who inspire me every day.

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1. WHY I STARTED A BACKYARD FISH FARM

With the economy biting hard and food prices sky rocketing I decided to grow my own fish and vegetables in my small backyard! It is amazing what you can accomplish when you put your mind to something. So obviously I googled 'how to grow fish in your backyard?' Google returned thousands of results but one particular term stood out – aquaponics, which is basically a combination of aquaculture (fish production) and hydroponics (plant production without soil). I then started actively reading up everything I could on aquaponics. Eventually this led me to YouTube where there were hundreds of do-it-yourself aquaponics system videos. I then realised that I could easily build this system on my own. And that is when it all started.

I have a civil engineering degree which I have never really utilised. After graduating from campus I immediately joined an accounting firm and started a career in finance and management. So this was completely new to me. However there is immense value in challenging oneself to do things outside your field of expertise or comfort zone. I knew it would be a steep learning curve and there would be many challenges but I was determined to make it happen. Plus the thought of being among the pioneers of aquaponics in Uganda was too appealing to pass on!

My aspiration was to experiment with the system and demonstrate that it works and then use it to teach and inspire as many people as possible to take it up within Uganda. Uganda is largely an agricultural society with a large majority depending on agriculture for survival. However most of it is subsistence and not modernised. Moreover we have many jobless youths on the streets who could benefit from such projects.

Through aquaponics I hope to inspire a new trend towards modern urban agriculture where households can produce agricultural products right in their homes. Aquaponics farming perfectly fits into this aspiration. Imagine if everyone in Kampala was able to grow their own food and have food security for their families? Clean, healthy organic food, free from pesticides and chemicals, etc. Also you can make some good money by the selling the fish and vegetables/fruits. And you get to learn so many new skills in undertaking such a simple project yourself.

If you have children setting up an aquaponics system is the perfect way to practically teach your children some valuable life skills; Your kids get to learn about biology; aquaculture; plumbing; electricity; chemistry; project management; economics; marketing; nutrition; cost management; crop management; hydroponics; carpentry; physics; problem solving; perseverance; entrepreneurship; the list is endless.

It is my hope that this book will inspire at least one person to take action and build their own backyard fish farm.

2. HOW AQUAPONICS WORKS

What is aquaponics?

Aquaponics is basically the combination of aquaculture (raising fish) and hydroponics (the soil-less growing of plants) that grows fish and plants together in one integrated system. This is not a new system and has been around for 100's of years. However there is a new trend especially in the West toward healthy organic food which has inspired a move towards aquaponics.

The fish and the plants are in a symbiotic relationship. After you have fed the fish in the water tank, the water gets dirty because the fish release waste in form of ammonia. Through a pipe, that dirty water is directed to the grow beds. The rocks have nitrifying bacteria, which breaks down the ammonia into nitrates which are good for the plants' growth.

With the ammonia gone, the water is clean and is then directed through a pipe to a water tank below the grow beds. Inside that water tank is a small water-proof water pump, which pumps the water back to the fish tanks, and the cycle continues.

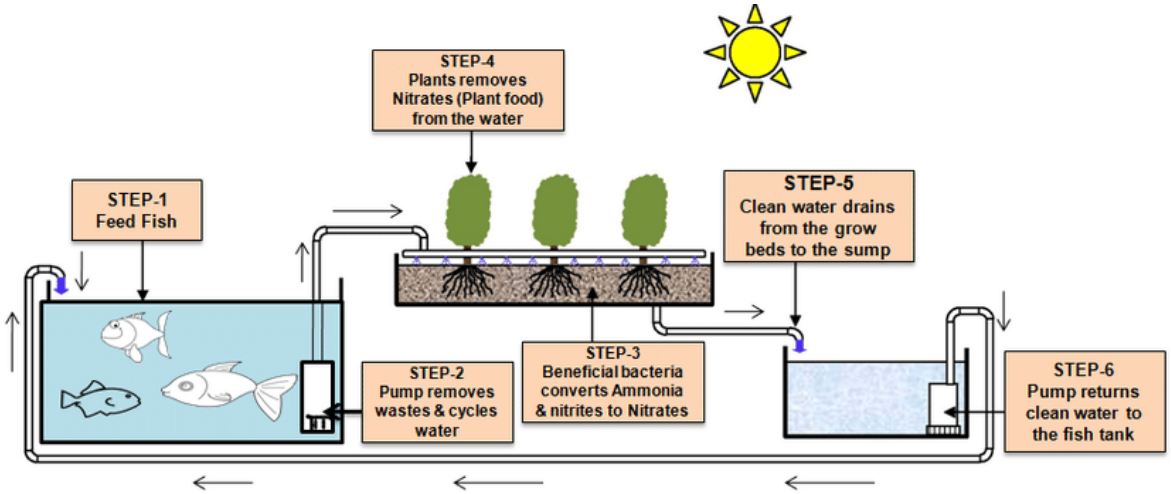
This simple system holds about 100 to 150 tilapia fish and cost me about Ugx 4m shillings. I will be able to harvest my fish in about 6months and my fresh lettuce within a month!

I also improvised covers on the fish tanks. They are made from a bit of wood and Iron sheets. These keep the birds from eating the fish and also block the sunlight from getting into the tanks as it would cause algae to grow. That takes away the oxygen from the fish.

Advantages of aquaponics

Some of the advantages of building your own home based aquaponics system include; Saves Space, No Weeding, No Soil Pests, No Watering, Offers a Source of Income, Plants Grow Faster, Less Energy, Less Back Straining, Healthy Eating, and it is sustainable.

The basic set up of the system is shown below:



A basic layout of an aquaponics system.

Step 1 – Feed the Fish: This is the main nutrient input into the system.

Step 2 – Pump removes wastes and cycles water: The pump(s) is the heart beat of the system and moves all the water around the system.

Step 3 – Beneficial bacteria converts ammonia and nitrites to nitrates: These are the tiny biological machines which convert the waste into food for the plants.

Step 4 – Plants removes nitrates (plant food) from the water: The plants feed on the nitrates in the process cleaning the water.

Step 5 – Clean water drains from the grow beds to the sump: Clean water then flows to the sump which is the lowest point in the system.

Step 6 – Pump returns clean water to the fish tank: The pump completes the cycle and runs 24/7.

3. PLANNING TO SET UP THE PROJECT

It took me about a whole year to move from initial idea to actual implementation of the project! This is a very long lead time I must agree. Following through is one area I have struggled with. We grow up with all these self-limiting beliefs; who am I to build one of the first aquaponics systems in Uganda; will it work; what if it fails; do I have the money; don't you have better things to do? I think the education system doesn't help much in this regard. We are taught to simply regurgitate information and are graded on how well we reproduce the information in a 3hour exam. We are not really taught how to identify problems in our environments and then actively research and implement viable solutions. I must admit I was always an A+ student back in school. But coming out of school I quickly realised I was not well equipped to handle and solve problems in the real world. So I started a new process of re-learning about life principally from books and the internet. I studied 100's of self-development books. I learnt how to program. I taught myself urban agriculture and modern farming. I ventured into spirituality. I read auto-biographies of Nelson Mandela, Mahatma Gandhi, Richard Branson, and Martin Luther King Jr.

One characteristic stood out from all these people. They pushed themselves beyond the ordinary and in the process they transformed themselves and heavily impacted their communities and the world at large.

So I thought to myself whether I could undertake this small project and forever change the agriculture landscape in Uganda. Maybe I was naïve at the time to think this but none the less I started acting on this ambition.

I began researching design and layout options for the project. Then I came with a bill of quantities with a cost estimate (See section 4). This estimate became a moving target as I really didn't know what items I needed. I would buy an item from a hardware shop then realise I bought the wrong one. I would the go back to the internet and research more and print out pictures of the parts which I would take to the hardware shop and explain to them what I wanted to do. Explaining to these people what I was trying to do was quite challenging and interesting. I would tell them I am doing aquaponics and they would reply: akwaa - waaati? One time I burst out laughing and the shop attendant gave me this look of 'oba onoo abadde kii?' meaning what is wrong with this one!

The names and types of plumbing parts was another uphill task. I didn't want to engage a plumber because I wanted to do it myself so I could learn. I then realised how my Engineering degree had not adequately prepared for basic plumbing work. To imagine that I was an Engineer who could not connect two pipes was really humbling. In times of complete ignorance I resort to my only true friends, Google and YouTube!

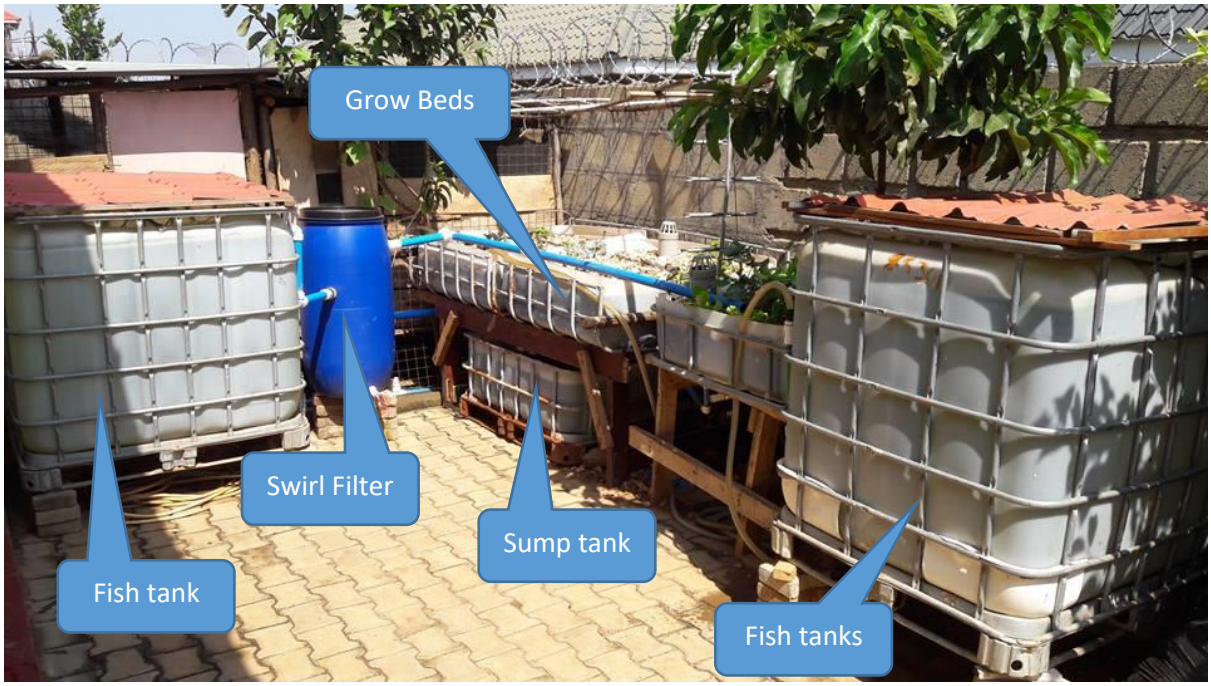
I then slowly started buying the materials. I bought the tanks first (four of them). We had an old bed which I repurposed to be a support structure for the grow beds. Building a support structure meant I now had to learn some basic carpentry. This was not that difficult though, but it was painstaking work!

I learnt the value of hard work through all this manual work I was doing. I would often go to bed with bruised hands, torn shirts, and a hurting back. I now respect the millions of men and women who do this kind of work on a daily basis. I became even more grateful for my comfortable and well-furnished office with air-conditioning. It is easy to take these small amenities in life for granted.

The basic system I had in mind looked something like this:

Basic design layout for my project (Christopher Somerville, 2014).

I decided to add an additional fish tank to the basic setup shown above. Below you can see the final set up. This was after several iterations to try and optimise the system. I had to buy power tools (grinder, drill, etc.) to be able cut up and join different parts.



Key Components of the System

Fish tanks: This is where the fish live and grow. In this set up I have two fish tanks with a water volume 1,000 litres each.

Swirl Filter: The swirl filter is a simple clarifier which removes heavy solids from the water before it pours into the grow beds.

Grow beds: This where you grow the plants. It is also where the beneficial bacteria convert the ammonia (fish waste) into nitrates (plant food).

Sump Tank: This is the lowest level of the system and collects all the water draining from the grow beds before it is pumped back into the fish tanks. The submersible pump is also located in the sump tank.

4. ECONOMICS OF PROJECT

Before engage in any enterprise it is important to know how much it will cost and if and when you will be profitable. To do this you need to know your project costs and expected revenues.

Project Bill of Materials and Costs

The following is a typical Bill of materials for an aquaponics system with 2 fish tanks, 3 grow beds, max fish capacity 200, 1 swirl filter, and 1 sump tank.

No	Item	UoM	Qty	Rate	Amount - UGX	Amount - US$	Notes
	Tanks						
1	IBC tanks - 1000ltrs	No	4	200,000	800,000	$ 229	
2	Filter tank	No	1	60,000	60,000	$ 17	
	Plumbing						
3	UPVC pipe (blue ones) 1,1/4"	No	3	35,000	105,000	$ 30	
4	Tank connector PVC 1,1/4" (white in colour)	No	5	15,000	75,000	$ 21	
5	Elbow PVC 1,1/4"	No	10	7,000	70,000	$ 20	
6	Tee PVC 1,1/4"	No	4	7,000	28,000	$ 8	
7	Socket PVC 1,1/4"	No	5	7,000	35,000	$ 10	
8	Tank connector PVC 3/4" (white in colour)	No	4	12,000	48,000	$ 14	
9	Flexible Hose - 3/4"	mtrs	30	3,000	90,000	$ 26	
10	Ball valves - 3/4" (taps)	No	5	20,000	100,000	$ 29	
11	Reducers 3/4" to 1/2"	No	10	3,000	30,000	$ 9	
12	Taps 1/2" (white in color)	No	10	7,000	70,000	$ 20	
13	Tee PVC 3/4"	No	3	5,000	15,000	$ 4	
14	UPVC pipe (blue ones) 3/4"	No	1	16,000	16,000	$ 5	
15	Socket PVC 3/4"	No	5	5,000	25,000	$ 7	
16	Elbow PVC 3/4"	No	5	3,000	15,000	$ 4	
17	Pipe PVC 4" (grey in colour)	No	1	30,000	30,000	$ 9	
18	Pipe PVC 2" (grey in colour)	No	3	10,000	30,000	$ 9	
19	End caps 2"	No	3	2,000	6,000	$ 2	
20	End caps 4"	No	3	3,000	9,000	$ 3	
21	Reducers 1" to 3/4"	No	3	4,000	12,000	$ 3	
22	Plumbing tape	No	5	3,000	15,000	$ 4	

No	Item	UoM	Qty	Rate	Amount - UGX	Amount - US$	Notes
23	PVC connector 1,1/4"	No	2	4,000	8,000	$ 2	
	Pumps						
24	Submersible pump (Flow rate 3500ltrs per hour, 60W, 240V, Max head-3m)	No	2	500,000	1,000,000	$ 286	One pump is for backup in case the other fails
25	Air pumps and accessories	No	2	100,000	200,000	$ 57	
	Electrical						
26	Electrical wire	mtrs	30	2,000	60,000	$ 17	
27	Socket 2-Way	No	1	15,000	15,000	$ 4	
	Accessories						
28	Gravel	Lumpsum	1	150,000	150,000	$ 43	
29	Supporting concrete blocks	No	40	3,000	120,000	$ 34	
30	Support lumber (3x4)	No	4	7,000	28,000	$ 8	
31	Lumber 2x2	No	2	5,000	10,000	$ 3	
32	Iron sheet	No	1	35,000	35,000	$ 10	
33	Binding wire	rolls	1	10,000	10,000	$ 3	
34	Fresh water test kit	No	1	250,000	250,000	$ 71	
	Tools and equipment						
35	Threading die 1,1/4"	No	1	35,000	35,000	$ 10	
36	Angle grinder and disks	No	1	150,000	150,000	$ 43	
37	Threading die 3/4"	No	1	35,000	35,000	$ 10	
38	Drill and drill bits	No	1	150,000	150,000	$ 43	
39	Hack Saw	No	1	10,000	10,000	$ 3	
40	Protective gear (gloves, googles, boots, etc.)	No	4	20,000	80,000	$ 23	
41	Pliers	No	2	15,000	30,000	$ 9	
42	Measuring tape	No	1	5,000	5,000	$ 1	
	TOTAL				**4,065,000**	**$ 1,161**	

Cost/Benefit Analysis of Project

There are many ways of assessing the financial viability of any project you wish to undertake. The easiest is to simply compare your revenue with your costs. As long as your revenues cover your costs you are in business.

The following is a simple cost benefit analysis for the project (Costs are in UGX). Basically you are able to recover your costs within a year and the project is profitable going forward.

	Year 0	**Year 1**	**Year 2**	**Year 3**
Costs				
Set up costs	4,065,000			
Fish feeds		600,000	600,000	600,000
Electricity costs		480,000	480,000	480,000
Total Costs	4,065,000	1,080,000	1,080,000	1,080,000
Revenues				
No of fish		300	300	300
Value of fish (UGX 15,000)		4,500,000	4,500,000	4,500,000
Value of vegetables		300,000	300,000	300,000
Total Revenue	**-**	**4,800,300**	**4,800,300**	**4,800,300**
Net Cash flow	(4,065,000)	3,720,300	3,720,300	3,720,300
Cumulative Cash flow	(4,065,000)	(344,700)	3,375,600	7,095,900
Break even	13 Months			

These costs and revenues are based on a design of 2 fish tanks and 3 grow beds as shown in section 4.

5. SETTING UP THE PROJECT

The chronological steps in setting up the project are as indicated below:

A: PREPARE THE FISH TANKS

I recommended using the used IBC containers. These are the white recycled containers with a capacity of 1,000 litres which are usually found on the roadside. I used them because they are quite strong because of the external metallic cage which surrounds them. Just make sure they are well cleaned and didn't carry any toxic chemicals. Also ensure they are not damaged and do not leak

They are also relatively cheap, are quite strong, durable and easy to work with. You need to give them a thorough wash to remove any chemicals.

Once cleaned you need to remove the top two bars which hold the container. You will need to use a hand tool - drill with hexagonal drill bits. After this you need to cut a rectangular hole from the top. You may use a grinder, or a hot knife or a small hack saw blade.

Cut two of the tanks into three grow beds and one sump tank. The grow beds should have a depth of at least 0.3m and the depth of the sump tank should be at least 0.5m.

Make sure you keep safe while using these power tools. If not please get a professional technician to assist you.

Cutting the IBC tank metallic frames using a grinder.

Laying out the plastic recycled tanks.

Assembling the tanks in a logical manner.

B: PREPARE THE SUPPORT FRAME

The support frame is used to hold the grow beds. It has to be very strong and firm. You can use concrete blocks, metal frame, or wooden frame.

In my case I used an old 3×6 wooden bed which I repurposed and reinforced. The bed should be able to hold the number of grow beds you wish to use. In this set up it needs to able to hold three grow beds.

Preparing the wooden support structure for the grow beds.

Wooden bed to act as a support structure.

Where to locate the aquaponics unit

This unit has a small footprint of only 5sqm so it can easily fit in a small backyard. A few things to consider though.

The area should be easily accessible, on firm ground, near a water source and with enough sunlight for the plants. It is probably best to place it in a corner so as not to use up a lot of space.

The grow beds should be placed in such a way so as to be accessible for planting, harvesting and maintenance.

If possible use a green house. This will increase your plant yields and keep away pests.

In some areas if you have a concrete rooftop you can utilise that space. The only challenge is carrying the heavy materials to the top.

The fish tanks will need to be placed in a shade or covered to prevent algae growth.

Layout of the fish tanks, sump tank, grow beds and support framework.

C: PREPARE THE GROW BEDS

The grow bed is where all the magic happens. It is where all the dirty water from the fish tanks is cleaned and filtered. It is also where you grow your fruits and vegetables. The grow bed contains millions of bacteria which convert the toxic ammonia in the water into nutrients for the plants.

The grow bed container can be anything affordable you can find as long as it is strong enough to hold the stones and is water proof. It can be a used basin, shower tab, jerry can, IBC container, bucket, etc.

After deciding which container you will use you need to consider which grow bed media to use. The cheapest and easiest to find around Kampala are these small stones (gravel) which they use to build houses. You can easily find them along the roadside where they sell sand usually in heaps. Buy the medium sized ones because they are easier to handle and provide good support for the plants.

Once you have delivered them to your site you need to give them a thorough wash to remove dirt and any impurities. Finally place the clean stones into your container.

Setting up the grow beds.

Grow beds set up with plants thriving.

D: PLUMB THE SYSTEM

Installing the Submersible Pump

The heartbeat of your plumbing system is a little submersible pump. This little pump is usually located within the sump tank and pumps the clean water from the grow beds back into the fish tanks.

In choosing the type of pump to use you need to consider its flow rate, maximum head and power consumption.

Typically a flow rate of at least 1000 litres per hour and a minimum head of 1.5m is good enough. The power consumption should also be less than 40W. The pump specifications will however depend on the design of the system.

You need to provide power access near your unit in a dry and safe environment to avoid accidents.

Sizing your pump for the aquaponics system

There are some basics in finding the right pump for your system. First you need to do your homework on basic system parameters. What is the total volume of water in your system? How high are the fish tanks? What are the sizes of your pipes and plumbing?

The pump should be a 240V AC pump with a power rating of about 40W to 100W. In sizing the pump the basic consideration is that the pump should be able to move all the water within the fish tank at least once every 2 hours. This ensures that there are no solids build up within the system and the water is constantly aerated thus increasing the dissolved oxygen.

In my system each water tank holds 1,000liters of water. The fish tanks are about 1.2m off the ground. The pump I am currently using is a submersible pump rated 110V, AC, 90W and has a maximum flow rate of 3,750 litres per hour. I had to buy a small transformer to step down the voltage from 240V to 110V. This pump runs 24/7 and costs me about UGX 40,000 in YAKA per month.

This pump actually delivers about 1,000liters per hour in the system. I measured this by timing using a phone clock how long it takes to fill a 20 litre jerry can and then extrapolating to 1,000liters. This means every hour all the water changes within the system. This is quite good for the system actually. To improve the flow rate further I optimized the plumbing by removing as many joints and bends as possible.

Sounds a bit complicated but once you get the hang of it, it's pretty basic stuff!

Typical submersible pump

Connecting the pipes

The main plumbing components in your system are the fish tanks, grow beds, sump tank, pump, and pipes/fittings. Each of these components is an entire chapter on its own.

The pipes come in different materials and sizes. The most suitable are the plastic ones (PVC or PPR) which are usually used for plumbing in your home. You also need tank connectors (also called long screw), tees, elbows, sockets, end plugs, ball valves, reducers, nipples, etc. A good plumber should be able to figure it out. Most of these parts are available in your local hardware or downtown around Nakasero market. You only realize the value of a good plumber when you attempt to figure this out on your own!!!

You will also need a flexible hose pipe to connect the pump to the fish tanks.

In plumbing the grow bed and the fish tanks there are three critical mechanisms which need to be plumbed; the auto bell siphon, the solids lift overflow and the swirl filter.

The Auto bell siphon

I am sure most of you reading this have used a flash toilet before!!!! Now when you pull the handle all the water flashes out of the toilet tank into the toilet sink. Now if you remember your secondary school physics well the water is able to flash out because of the siphon effect.

Well the auto bell siphon tries to replicate this flashing mechanism but in a more clever way. It does it automatically. There is no need to pull any handle.

So when the water in the grow bed fills up it automatically flashes out into the sump tank. This way the plants are never water logged and the flashing action helps to aerate the water and pull in useful oxygen for the bacteria in the grow bed. The grow beds also never overflow.

I get it this might be a bit complicated if you are reading this for the first time but a little research on google will help. Once you get the handle on it you can easily make yourself one.

Stand pipe, long screw, siphon, and guard.

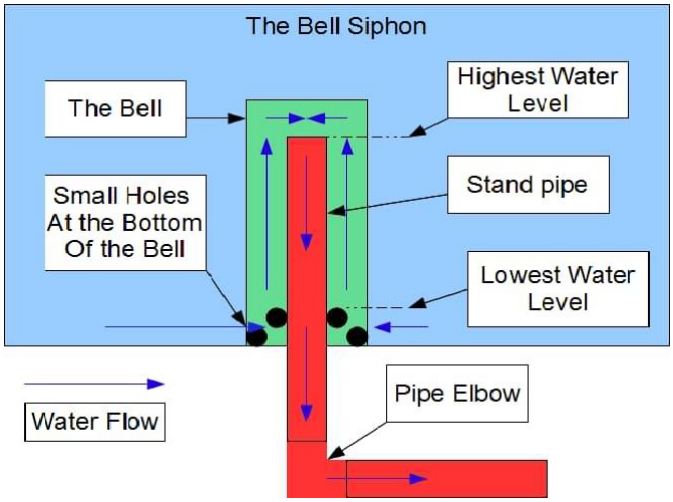


Image showing working mechanism of bell siphon.

The Solids Lift Overflow (SLO)

The fish in the tanks will pee and poo in the water. The pee and some of the poo dissolves in the water and will flow to irrigate the grow beds.

However most of the solids settle at the bottom of the tank. This makes the water dirty and not conducive to the fish. Moreover as these solids decompose they use up the oxygen in the water leaving none for the fish. If the poo is not removed the fish may die.

In order to remove these solids we use the Solids Lift Overflow (SLO). The SLO is simply a pipe with small holes at the bottom. The solids are pulled up by capillary attraction up the pipe and into the grow beds. It is similar to how you use a straw to drink soda. The SLO also regulates the level of water in the tank.

You need to add a simple filtration mechanism to catch these solids once they leave the tank. These solids are very good manure for your other soil based crops.

Solids Lift Overflow.

The Swirl Filter

The swirl filter is simply a clarifier which is added between the fish tank and grow beds. Its purpose is to remove heavy solids from the water before the water goes to the grow beds. The solids drop to the bottom of the tank by gravity where they are periodically drained out. This prevents the grow beds from clogging and developing anaerobic conditions. A simple used barrel tank will do the job perfectly.

Blue Barrel tank used as a swirl filter. They are usually sold by the roadside.

6. ALL ABOUT FISH

For your aquaponics system you will need to decide which type of fish to grow. In deciding which fish to grow you will need to consider several things.

Firstly you need to consider fish which grows well in our tropical climate and in fresh water. So don't expect to grow Salmon in Kampala. Tilapia, Nile Perch and cat fish all do well in tropical climates.

Secondly you should be able to easily and affordably access the baby fish (fingerlings) from a nearby farm. There are several farms you can get good quality fingerlings including the Aquaculture research Center in Kajjansi on Entebbe road.

Thirdly there needs to be a ready market for your fish. In Kampala I think Tilapia is most popular followed by Nile Perch and then Cat fish.

For my aquaponics unit I chose Tilapia because we have grown up eating it and there is a ready market for Tilapia.

A picture of cat fish.

The five needs of fish

Fish don't ask for much. In fact, they only have five basic needs: clean water, oxygen, food, light and room to swim. Give your fish these things, and they will stay healthy and grow fast. The art of fish farming is to understand each

of these needs, and then find a way to provide them in sufficient quantities. The problem is, that each of these five needs comes with a myriad of potentially complicated questions, and solutions (LakeWayTilapia, 2018).

Clean water

Fish live in water and as such the quality of the water you use in your fish tank is very important for their well-being.

The easiest rule of thumb is that you should be able to drink the water you put in your fish tank. The water should be clear and free from any visible impurities. Tilapia live in fresh water so the water should not have any salt.

The water should have a neutral PH. It should neither be acidic nor alkaline. The water should have very low levels of ammonia and nitrites. The water temperature should not be an issue in Kampala since tilapia live in relatively warm waters.

The water should have sufficient levels of dissolved oxygen to support the fish. The level of dissolved oxygen can be increased by using an air pump and air stones within the fish tank.

One way to monitor the water quality is to use a portable water test kit though these are not so easily available locally.

At the start of the project you will experience several fish deaths as the ammonia levels rise initially. After about 4 to 6 weeks a bacterial colony will establish itself in the grow beds. These bacteria will convert the ammonia into nitrates which are taken up by the plants. Once this happens the system is said to have cycled. Ammonia levels will drop significantly and the fish stop dying.

Testing Water Quality

I bought a water test kit which I use to monitor the most important water quality parameters. The most important parameters important to the wellbeing of the fish are; PH, Ammonia, Nitrites, and Nitrates.

To measure a specific parameter you add a small quantity of the water in the test tube and add a few drops of the appropriate regent. The water changes colour which you then compare to card to take the reading. For instance the ammonia reading in the attached image is about 0.25 ppm (parts per million).

PH is the acidity or alkalinity of the water and the reading should be neutral about 7.0. Ammonia and Nitrites should be close to 0.0ppm. Ammonia and nitrites are very toxic to fish. Readings above 0.0ppm may indicate too many solids in the system or that the bacteria is not working effectively. Nitrate reading can be as high as possible. Nitrates are good for the plants and their presence indicates the nitrifying bacteria are working well.

Taking an ammonia reading.

Interpreting the results

Oxygen

Fish obviously breathe oxygen and depend on it for survival. However they can't breathe in the oxygen you and I breathe in. It has to be dissolved in the water for it to be available to the fish. There are many factors which affect the amount of dissolved oxygen in the water including the surface area of the exposed surface, the water temperature and the surface tension of the surface. In my system I used simple mechanisms to increase the level of dissolved oxygen. First you need to make sure the water is constantly moving. That means the pump runs 24/7. You don't want stagnant water anywhere in the system. Also make sure at least every two hours all the water in the fish tanks moves through the grow beds. I also use an auto siphon mechanism in the grow beds. What this does is it flashes all the water in the grow bed into the sump tank. This agitation of the water actually breaks the surface tension of the water and allows the oxygen to dissolve into the water. I have also installed a few air stones in the fish tanks. The air stones are connected to small air pumps which run 24/7 on power.

Try to prevent algae over-growth as much as possible as it consumes oxygen especially during the night. Also don't over feed the fish. Because any un-eaten food will decompose within the system and may clog pipes. As the uneaten food will used up the precious dissolved oxygen.

Food

In case you didn't know fish need to eat a well-balanced meal! In our case we buy fish pellets from a reputable feed mill. Pay attention to the protein content and the size of the pellets. Use feeding charts to determine the amount of food to give. Generally feed in proportions relative to their body weight. However I use a simple rule of thumb. I throw some pellets into the water and if there are uneaten pellets after 15mins I stop feeding.

We generally feed three time a day. Morning, Afternoon and Evening. It is best to use floating fish pellets as you can monitor the feeding behaviour.

Light

It's very clear that tilapia need light to survive. Without light, they won't move or eat, and they will die (LakeWayTilapia, 2018). There is plenty of sunlight in the tropics as long as the fish tanks are located outside. This will be sufficient.

Even if the tanks are in a shaded spot the light reaching them will usually be sufficient.

If the system is indoors you need to provide an artificial light source. Fluorescent bulbs are mostly used and work well enough. There are some fancy submersible lighting sources but you can do without them.

Room to swim

Fish need sufficient room to move around and enjoy themselves. Overcrowding causes stress that leads to slower immune system response and poor resistance to disease (LakeWayTilapia, 2018). Since we are using a 1000 litre tank you must prevent overcrowding. Overcrowding is dangerous for various reasons. If you have too many fish in the system and you get an extended power failure you could easily lose all the fish. This is because the fish will quickly use up the oxygen in the system. Also they will release huge amounts of ammonia which is very toxic. Overcrowding may overload the grow bed with a lot of ammonia which may render the grow beds ineffective. This will lead to a gradual build-up of ammonia in the system.

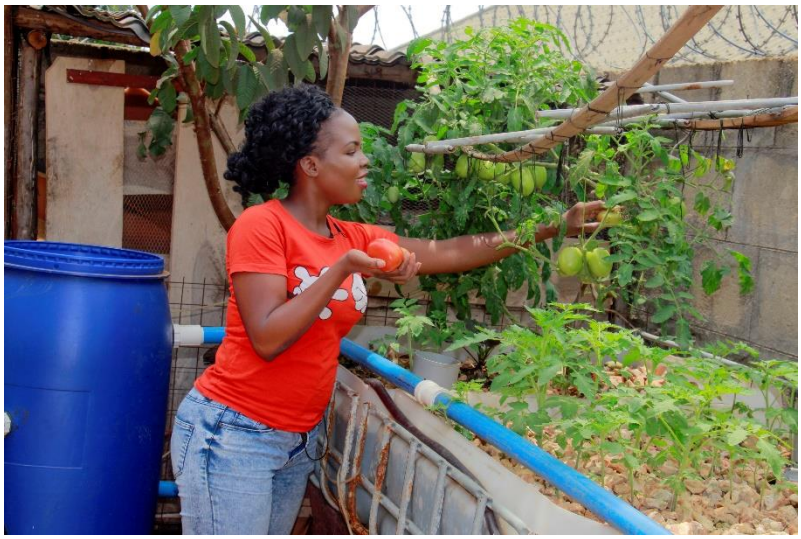
7. GROWING VEGETABLES IN YOUR GARDEN

There are several ways to grow your plants. You can start from seed or transplant into the grow beds (Stout, 2013). It is much easier to actually grow crops in the aquaponics system. First of all there is no soil therefore there are no soil borne diseases and pests. Also you don't need to worry about water and nutrients as these are always available in the system.

We have planted tomatoes which did quite well in the system. We planted lettuce as well which blossomed and we have enjoyed a couple of salads and sandwiches!

We planted a few onions though they didn't perform so well. The cucumber grew so wild and had taken over the entire grow beds. I uprooted most of them and left only two. Most people at home don't really like cucumbers so I had to remove them from the system. It is important to plant things which are regularly eaten at home.

We planted a few herbs as well, mint, peppermint, and oregano. These are used to spice our food. A couple of spinach plants, beetroot and okra are part of the garden as well.



Harvesting ripe tomatoes from the aquaponics garden

Managing Pests and Diseases

Pests can be quite a nuisance in the system. They will attack and destroy your plants if not well managed. We have rats, snails, insects, birds, and mosquitoes all becoming a pain. The tomatoes have been attacked by various

fungal infections. Remember you can't use any toxic chemicals to spray the plants because you will kill the fish. Pest insects can be root borers, sap suckers, or leaf munchers (Stout, 2013).

Pest deterring plants

You can plant pest deterring plants like garlic and peppermint (Stout, 2013). Many insects don't like the smell and taste from these plants and will keep away from your garden.

Organic sprays

For sprays you can simply use a splash of water to wash away bothersome insects. You can also make garlic fire spray by blending 20 to 30 cloves of garlic and 5 to 6 hot chili peppers together in a couple of liters of water with a large spoonful each of salad oil and dish detergent (Stout, 2013). You can also use neem oil as a spray. Diluted neem oil can be effective as a pesticide and can control various fungal diseases, such as powdery mildew, on animals and plants (Stout, 2013). You can also use sticky traps to manage insect pests. The traps should be close enough but away from the system because these traps may contain some chemicals which are toxic to the fish.

Rat traps

Simple rat traps can help reduce the incidence of rats. Also keep away food from access of rats. Rat poison should be used carefully as it can be dangerous for both kids at home and the fish.

Controlling birds

Birds usually eat our young seedlings and seeds. They also come to the garden to drink water and in the process leave droppings in the system. These droppings may contain pathogens which may infest the fish. You can use a simple net to cover your garden and keep away the birds. One may also use scare crows though I am not so sure how effective this would be.

Plant Nutrition

I am not an agronomist but quickly realised that plants also need to have a healthy balanced meal. The biological processes which enable a plant to grow from a tiny seed to a fruit yielding plant are quite complex and beyond the scope of this book.

The key non-mineral nutrients plants need are Oxygen, Hydrogen, and Carbon. You don't really to worry about these because nature will supply these in abundant forms (Storey, 2018).

The Primary Mineral nutrients include Nitrogen, Phosphorous and Potassium (Storey, 2018). These will be mainly sold as NPK and will be readily available with agro-distributors. Different relative proportions of NPK will be applicable at different stage of plant growth. Generally in early plant life you need a higher proportion of Nitrogen to stimulate vegetative growth. As the plant grows you increase the proportion of Phosphorous and Potassium. As fruiting emerges the Potassium should be increased to encourage fruit development.

The Secondary mineral nutrients are Magnesiun, Calcium and Sulphur. Common micro mineral elements in aquaponics systems include Iron, Copper, Zinc, Manganese, Boron, and Molybdenum (Storey, 2018). The chemistry and interactions of these nutrients is well beyond the scope of this. All these nutrients are important for plant growth. I encourage to read more on this matter from the sources quoted in the bibliography and various other sources on the internet.

In our system I have not bothered much to manage these nutrients. I simply control the number of plants, remove pests, and give the plants plenty of sunlight. I also stick with simple things to grow like lettuce and other leafy vegetables. Fruit vegetables like tomatoes are a bit tricky as they need more nutrients and are easily susceptible to pests and diseases.

8. DAILY MANAGEMENT ROUTINE OF YOUR FISH FARM

Once you have set up the system and it has fully matured the daily maintenance is really minimal and limited to only 10 to 30mins daily. This is a typical timeline of the daily routine.

6.30am – Just before leaving for work. Visually inspect fish, plumbing, electricals, pumps, plants. Look out for any distressed fish or plants. Visually inspect the quality of water. Water should be clear and not murky. Make sure there are no water leakages or blockages and pump is working. Remove and dispose of any dead fish.

All activities when you are at work or not available should be delegated to someone else who stays at home. Make sure you train them first and write down clearly the instructions. This way you build capacity for your project and free yourself to do other things.

8.00am – feed the fish. Teach someone who stays at home how to do this.

1.00pm – feed the fish

5.00pm – clean fish tank. Remove any solids settling at the bottom of fish tank. Pour these solids in your soil based vegetable gardens. Remove about 20 litres of water from each fish tank and use it to irrigate your other soil garden plants. This water is very rich in nutrients. Top up the fish tanks with fresh clean water.

6.00pm – feed the fish.

8.00pm - After returning from work. Visually inspect fish, plumbing, electricals, pumps, plants. Ask your caretaker if the fish are fine and all the tasks were done according to schedule. Visually inspect fish, plumbing, electricals, pumps, plants. Look out for any distressed fish or plants. Visually inspect the quality of water. Water should be clear and not murky. Make sure there are no water leakages or blockages and pump is working. Remove and dispose of any dead fish.

On a weekly basis if you have the equipment take measurements of the ammonia levels and the water PH. Also create a simple book and maintain the following records; total number of fish, number of dead fish, fish weight, amount of food fed per day, water test results, number and type of plants, age of plants and fish, running costs, revenue from sales, etc.

You should budget for at least 10 to 30 mins of your personal time dedicated to this project per day. This way you get to really understand what is going on and how to trouble shoot problems and improve performance.

9. FREQUENTLY ASKED QUESTIONS

In this section I highlight the commonly asked questions and their appropriate responses.

Does the aquaponics system use soil?

This system does not use any soil whatsoever. The plants grow within the grow bed media or simply float in the nutrient rich water. This makes system very clean and less prone to soil based pests.

How much does the system cost?

You can build a system for as little as UGX 1 million using only one fish tank. For a system based on 2 tanks and 3 grow beds it will cost you about UGX 4 million.

What is the maximum number of fish per tank?

For a 1000 litre tank I would recommend a maximum of 100 fish. You need to start with less than 50 fish per tank. As your knowledge and skills increase you can gradually increase the numbers?

Where did you learn all this from?

Mainly from various resources on the internet.

Did you build the system yourself?

Yes I built the system on my own. I had to buy the right tools and equipment. I also had to teach myself basic carpentry, plumbing, electrical wiring, water chemistry, vegetable growing, fish biology, water physics, etc. The experience was extremely rewarding. If however you don't have the time to do it on your own you can get someone to help you with the set up.

How long did it take you to set up?

It took me about one month to set up mainly because I was only working on weekends and was learning how to build and buy the right materials and equipment. With more experience gained this can be set up within just one weekend.

How much area does the system occupy?

If you are using one tank the system will take up only one square meter. If you are using 2 fish tanks the system will occupy about 6 square meters (imagine three 3x6 beds placed side by side).

What do you feed the fish on?

There is fish feed available on the market but once you know the ingredients you can make it yourself at home.

How much power does the system use?

About UGX 40,000 per month.

What happens when power goes off?

There is an emergency plan for when power goes. First is DC powered back up pumps which use rechargeable batteries. If you don't have these use a jerry can filled with water and let it slowly drip into the fish tanks. You can also run a hosepipe from an overhead tank to the fish tanks. If funds allows consider installing a solar back up. Use inverters if you have them installed at your home.

Where did you buy the young fish (fingerlings) from?

I bought the fingerlings from a commercial fish breeder within the neighbourhood. You can also get them from the Aquaculture Research Center in Kajjansi.

How long does the fish take to grow?

Fish typically take 6 – 8 months to reach maturity or about 500gms.

Does the water smell?

No there is no foul smell. In fact the farm is very refreshing with the sound of splashing water and the fresh air from the vegetables.

I didn't study sciences, can I still do this?

Yes you can achieve anything in life you set out to do if you are committed, passionate and resilient.

10. TROUBLE SHOOTING COMMON PROBLEMS

As part of running any project or business several things will usually go wrong. It helps if you have some kind of plan for identifying and correcting issues. Below I will review the most common issues I have encountered so far.

Fish are dying

This can be very distressful for a newbie like me. Fish die for a number of reasons. They might be sick or infested with pests. It could be physical injuries during transportation or it might be poor water quality. The most common cause however is the poor water quality resulting from high ammonia levels and low oxygen levels.

The immediate thing to do is to change about 20% of the water in the fish tanks. Also immediately decrease the amount of fish feed given per day. Changing the water will reduce the concentration of ammonia which is toxic to the fish. You also need to clean the tank and remove any solids at the bottom.

To increase oxygen levels buy an air pump and add an air stone to the fish tank. You can also add a little device called a venturi on the hose pipe from the pump. Further let the water flowing into the fish tank create a splashing effect. This will ensure that the water surface is in constant motion thus increasing the level of dissolved oxygen in the tank.

Also increase the water flow rate if you have an adjustable pump or simply use a tap/valve. This will in effect cause the water to flow faster adding oxygen to the system and quickly removing ammonia from the fish tank into the grow beds.

Monitor the fish health on a daily basis. Healthy fish will be active and playful. If you notice fish seemingly struggling for air near the surface then this could be a sign of low oxygen levels. The fish should also be free from any physical injuries.

Pump is not working

You need to quickly fix this problem as the pump is the heart of the system. Without it the water will not recirculate. Check if power is on and that the power code is correctly plugged in. Check if there are no blockages in the plumbing from the pump. If you have done everything and still the pump does

not work it maybe because the pump is "dead." You need to make sure you always have a backup pump. Since the delivery of pumps takes a while having a backup pump will save your project in such eventualities. It is like having a spare tyre in your car when you are driving upcountry.

If you have no backup pump you will need to use a manual system to periodically remove the water from the fish tank and pour into the grow beds.

To mitigate problems with power failure consider installing a solar system or a small back-up generator. However the initial costs for setting this up may increase costs and render the project un-feasible in the short run.

There is a leakage

This will be because of poor workmanship of external tampering by someone or the kids at home. Make sure you good quality materials and fittings. Also ensure you use plumbers tape to seal off all joints. Provide a physical barrier to isolate system from kids and other people. Educate members of the household how to handle the system. Finally make sure you inspect the system daily to identify and fix any leaks before you lose everything.

Plants are not growing well

This will be most likely as a result of insufficient nutrients in the grow beds. It may also be because of inadequate sunlight, overcrowding of plants or disease/pest infestation. It may also be because of poor seed varieties.

Insufficient plant nutrients may indicate that the nitrifying bacteria are not thriving well in the grow beds. This may happen because of insufficient aeration in the grow beds. You may need to wash up the grow bed media and remove all debris and un-eaten fish food and waste. Thereafter you will need to recycle the system to allow the bacteria to recolonise the media. This may take up to 2 -3 weeks.

Where you have insufficient sunlight you may need to relocate the system to an open place. In cases where there is overgrown vegetation which is causing the shading you may need to trim it down.

For cases of overcrowding simply reduce the number of plants per grow bed.

Disease infested plants need to be removed. You need to implement an organic integrated pest management program. For example sticky traps will help to reduce the incidence of several pests.

Where the problems emanates from poor seed varieties make sure you procure good quality seeds from reputable suppliers.

Fish are growing slowly

This could be as a result of feeding problems. The feed quantities maybe inadequate or the quality maybe poor. I recommend sourcing feeds from trustworthy suppliers. Also make sure the fish are not crowded and that the water quality is good. Finally make sure you source fingerlings from a trustworthy breeder as well.

There is a lot of algae in the system

A lot of algae is not good for the system. Algae uses up oxygen in the water and clogs pipes and the grow bed. Algae thrives when you have exposed water surfaces in the systems. The remedy is to simply cover up the fish tanks and any other exposes water surfaces. Alternatively you can locate the fish tanks under a shed on inside the house. The grow beds however need to be outside in the full sun as the plants depend on the sunlight for their growth.

The pump is running dry

This may happen if there is a leakage or some evaporation has occurred and the water levels have dropped. In this case find and fix the leakages. Also top up the fish tanks with clean chlorine-free water. Make it a weekly habit to add some fresh water every week to compensate for evaporation.

Pests and diseases have infested the plants

The easiest remedy is simply to remove the diseased plant and destroy them. You are not supposed to use any chemical pesticides or other chemicals because they will contaminate the water and the fish will die. Use appropriate prevention methods to prevent infestation like using the right seeds, using organic sprays, physically removing pests, or covering the crops with a net.

The Water is too cloudy and the Grow beds are clogged

The Japanese have a word called "kaizen." It simply means "change for better" or continuous improvement. Hundreds of business/management books have been written about this philosophy and it is the heart of Toyota's famous production system. So in undertaking this little aquaponics project I try to continuously improve, treating mistakes and errors as learning points which I then use to improve the system.

The water became cloudy and the grow beds became clogged. The fish were distressed and a few died. The system developed anaerobic conditions because of poor solids management. Basically the fish waste and feed remains were not being properly handled. As these solids decomposed they used up most of the oxygen in the tanks leading to fish death. Also a lot of ammonia was released into the system further compounding the problem. The problem was further compounded when the biological filter was no longer effective and could not remove excess ammonia because some of the nitrifying bacterial had died off.

This called for a complete redesign of the system. I installed something called a swirl filter. A swirl filter is simply a tank (the blue one in the picture) where the water from the fish tank slowly rotates and any solids drop to the bottom where they are then drained off.

Also the tomatoes were hit with a fungal infection which spread to some of the fish. I had to remove all the tomatoes unfortunately and performed a complete water change. I also had to clean the gravel using a water jet to remove all anaerobic zones.

I also bought a water test kit. This way I can monitor the quality of water. Testing the water using the kit brings back memories of O-level chemistry and it is quite easy to do!

There is no power

We did not have power for 3 days and as the aquaponics system relies on power this was a real crisis! In moments of crisis you need to remain calm and sober and figure out an effective solution.

When there is no power the pump doesn't run meaning fish waste including ammonia begins to build up. If nothing is done the fish will die! Immediately we connected a water hose from the tap and let the water trickle slowly into

the fish tank. This worked well until day 3 when the water ran out of the tap. The estate didn't have power to pump water as well! So I woke up at 5.30am on Sunday morning to try and save the little fish.

First thing was to test the ammonia levels using a portable water test kit. The reading was about 0.5 parts per million (ppm). This is getting into the danger zone so I immediately took on the work the pump usually does. I siphoned water manually from the sump tank and poured into the fish tank. I also ran another siphon from the fish tank into the swirl filter. I kept doing this for about 2 hours until the ammonia levels dropped to 0.25ppm.

I suspended feeding for the whole day as well to avoid introduction of new ammonia sources into the system. Finally I improvised by placing a jerry can with small holes on top of the fish tank and let it slowly drip. This helps to aerate the water and dilute the ammonia waste.

I kept doing this routine throughout the day and it was back breaking work!

Finally power came back around 5.00pm and the day was saved. The fish eventually had a meal.

We didn't lose any fish!!

Fish are reproducing too much

The tilapia as reproducing too much and the numbers were too many. The system can support only a few fish. As a result I was forced to introduce catfish because it cannibalises on the young fingerlings thus controlling the numbers.

Kids are playing with the system

This can be potentially dangerous as kids may fall into the fish tanks, tamper with electrical wiring and open water valves which may drain the entire system. You need to install simple physical barriers to prevent access. But also educate the entire household about basic safety risks and procedures on a regular basis.

11. BIBLIOGRAPHY

Christopher Somerville, M. C. (2014). *Small-scale aquaponic food production.* Rome: Food and Agriculture Organisation.

LakeWayTilapia. (2018, April 13). *The five needs of Tilapia*. Retrieved from lakewaytilapia: https://lakewaytilapia.com/How_To_Raise_Tilapia.php

Storey, N. (2018, April 17). *How to Manage Plant Nutrients in Aquaponics*. Retrieved from YouTube - Bright Agrotech: https://www.youtube.com/watch?v=Lgtue6tbbhc

Stout, M. (2013). *The Complete Idiot's Guide to Aquaponic Gardening.* New York: Penguin Group (USA) Inc.

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John is an Engineer and a professional accountant. He has over 10 years' experience in consulting, strategy, business, management, audit and finance. John has used his background to demonstrate that you can sustainably establish a backyard fish farm right here in Uganda. He has also established a demonstration urban farm right in his back yard which is open and free to the public. John is one of the pioneers of aquaponics in Uganda. He offers free site tours at their farm.

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