Aquaponics System

Aquaponics is an integrated fish and plant production technology, essentially comprising of two sub-systems, viz., '*Aquaculture*' and '*Hydroponics*'. The underlying principle is to efficiently utilize water to produce two crops rather than one and to partition and share nutrient resources between fish and plants. This farming system is commonly used in resource limited and urban areas to raise both fish and vegetable in an integrated system. Aquaponics involves culture of horticulture plants along with fishes. Many plants are suitable for aquaponics systems, though which ones work for a specific system depends on the maturity and stocking density of the fish.

Green leafy vegetables with low to medium nutrient requirements are well adapted to aquaponics systems, including capsicum, tomatoes, lettuce, cabbage, lettuce, basil, spinach, chives, herbs, and watercress. It is basically a Recirculation Culture System, wherein fish are fed with quality floating pellet feed and waste generated from fish are pumped into bio-filter troughs having horticulture plants, the flow rate of water is to be adjusted with the help of the timer. The fishes and plants grown in aquaponics system are totally organic.

Even though the initial investment of the system is high, the recurring cost is less and gives reasonable returns. This system is having the advantage of using less water, lesser area of land, waste renewal, less labour, etc. Plants and animals in an Aquaponic System have a symbiotic relationship with each other. The fish excreta provide nutrients for the plants, while the plants clean the water, creating a suitable environment for the fish to grow.

1. Resources

Aquaponics is often hailed as the future of food production. Aquaponic Systems are said to utilize only 2 to 10% of the water required in traditional vegetable or crop production and have the potential to produce 10 times the output, without the use of harmful chemicals, pesticides, etc. The most significant aspect of Aquaponics is the minimum extent of land/ space required, leading to what is being dubbed as Urban Aquaponics/ Urban Agriculture/ Urban Farming/ Urban Gardening/ Terrace Gardening/ Vertical Gardening/ Office Farm (indoor), etc. Being highly efficient, utilization of natural resources is very limited and results in conservation of precious natural resources like water, land and environment.

2. Status and Potential

Our country is leading in freshwater fish production as farmers have achieved impressive yields even in traditional methods of fish farming by harvesting anywhere between 2–10 tonne per hectare per year. However, an Aquaponics System can produce up to five times the quantity of fish in same area per year, besides a good crop of vegetables. Aquaponics is relatively a new practice in our country. Establishment of these units will therefore improve the knowledge base of fish farmers about emerging and future technologies in aquaculture.

Operation of these units is more demanding in terms of technology, techniques, biology of cultured fish and stringent water quality parameters. In view of the shrinking resources of land and water, growing population, urbanization and change in life-style, there is a great demand for fresh, hygienically and organically produced fish and vegetables in the cities. Therefore, Aquaponics has a huge potential for integrated fish and plant production in urban, suburban as well as rural settings.

3. Project Location and Implementation

A. **Site Selection:** Selection of a good site is extremely important, although Aquaponic Systems are suitable where only limited water is available for removal of fish wastes out of the production system. Passing water through a treatment unit removes ammonia and other waste products achieving the same effect as a flow-through configuration. Land/ space measuring at least 150 m^2 for a Backyard-type Aquaponics unit and 2000 m^2 for a Small-scale Commercial Aquaponics unit is required for the construction.

B. **Beneficiaries:** Beneficiaries include women SHGs/ fisherman societies/ fish farmers/ entrepreneurs; selection would be based on their interest and awareness. Beneficiary selection is done through a notification and NFDB Website.

C. **Project Implementation:**

- Project will be implemented by the beneficiary with technical support from the Designated Technology/Service Provider and Dept. of Fisheries of the State Govt.
- Financial assistance in the form of subsidy will be obtained from Govt. (Central/State) and the remaining amount will have to be borne by the beneficiary through self-finance, bank loan, etc.

4. Project Components

A. **Water Quality:** Water quality is important and optimum range of certain parameters required for successful fish culture in an Aquaponics System are as follows:

Sl. No.	Water Parameter	Optimum Range
1	Temperature	26 - 30 ^{o}C
2	Dissolved Oxygen	4 - 6 ppm
3	pH	7 - 8
4	Alkalinity	120 - 150 ppm
5	Ammonia	<0.05 ppm
6	Nitrite	<0.5 ppm
7	Nitrate	<5 ppm

B. **Targeted Fish Species:** Monosex Tilapia (*Oreochromis niloticus*), Pangasius (*Pangasiandon hypophthalmus*) or any species that can tolerate high density stocking are suitable for Aquaponic System.

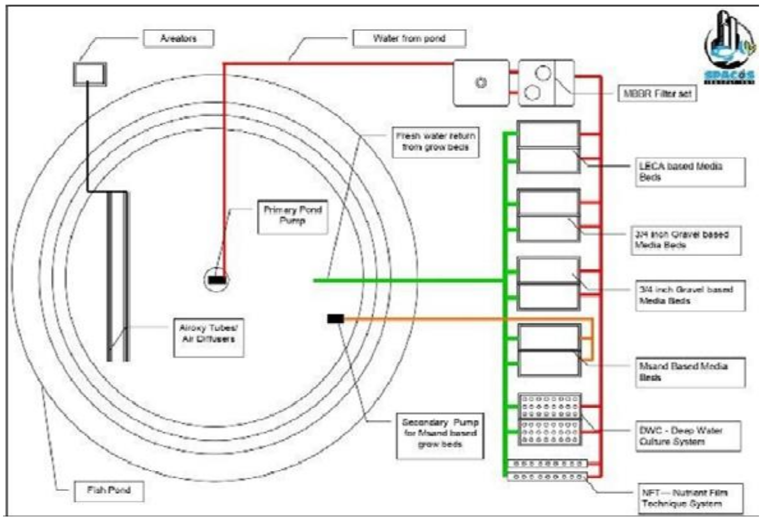
	
GIFT Tilapia (*Oreochromis niloticus*)	Pangasius (*Pangasiandon hypophthalmus*)

C. Model Unit: Particulars of the 'Small-scale Aquaponics Unit' designed by M/s Spacos Innovations, Chitradurga, Karnataka are given here as an example:

(i) Fish Pond/Tank: Area required for construction of the fish pond/tank is 80 m^2; diameter of the circular tank is 7.2 m, having a volume of 60 m^3 (60,000 litre), with effective water depth of 1.68 m and maximum depth of 2.13 m (centre of the pond/tank). The system is designed to handle more than 50 fish/m^3 (total 3000 fish). Details of design of pond/tank are as follows:

Sl.No.	Particulars	Unit
1	Total Land Area required	Maximum of 150 m^2
2	Tank Area	80 m^2
3	Circular Tank Diameter	7.2 m
4	Tank Volume	60 m^3 (60,000 litre)
5	Effective Depth	1.68 m
6	Maximum Depth	2.13 m (centre of the pond)

(ii) Plant Grow-Beds: Number of grow-beds in FRP Tanks 10, dimension of each grow-bed 6 x 2 x 1 ft (1.83 x 0.61 x 0.30 m); different kinds of solid media such as gravel or expanded clay pebbles (hydrotons) or lightweight expanded clay aggregate (LECA) are used to grow plants, through which water from fish tank passes. Design and layout of the fish tank and grow-beds is shown below:



Layout of Small-scale Aquaponics Unit

(iii) Moving Bed Biofilm Reactor & Filtration: One Moving Bed Biofilm Reactor (MBBR) and Filtration Unit is installed for water treatment in the Aquaponic System.

Fish Tank and Filtration System

Plant Grow-bed Tanks

(iv) Stocking and Yield: Although stocking densities should be determined by species requirements and operational considerations, the influence of stocking densities on growth and production has been determined empirically. The indicative stocking and harvest details of fish and plants are as follows:

Sl.No.	Component	Salient Feature
I	**Fish Culture**	
1	Fish Tank volume	60 m^3
2	Moving Bed Biofilm Reactor & Filtration Unit	One Set
3	Targeted Species	GIFT Tilapia (*Oreochromis niloticus*) and Pangasius (*Pangasiandon hypophthalmus*)
4	Fingerling stocking (50/m^3)	3000 nos.
5	Fish Culture period	5-6 months
6	Survival	90% (2700 nos.)
7	Average body weight	750 g
8	Expected Yield/unit/cycle	2700 fish x 750 gm = 2025 kg
9	Total Production/unit/year	2025 kg x 2 cycles = 4050 kg per year
sII	**Vegetable Cultivation**	
1	No. of Plant Grow-beds	10 nos.
2	Plant varieties	Tomato, Mint, Chilly, Lettuce, Basil
3	Planting density	15 – 20 saplings / bed
4	Total no. of Plant	150-200 plants
5	Plant cultivation period	Throughout the year
6	Harvest type	Partial harvest
7	Expected yield /bed/year	5-10 kg/ bed/ year

5. Commercial Aquaponics Unit

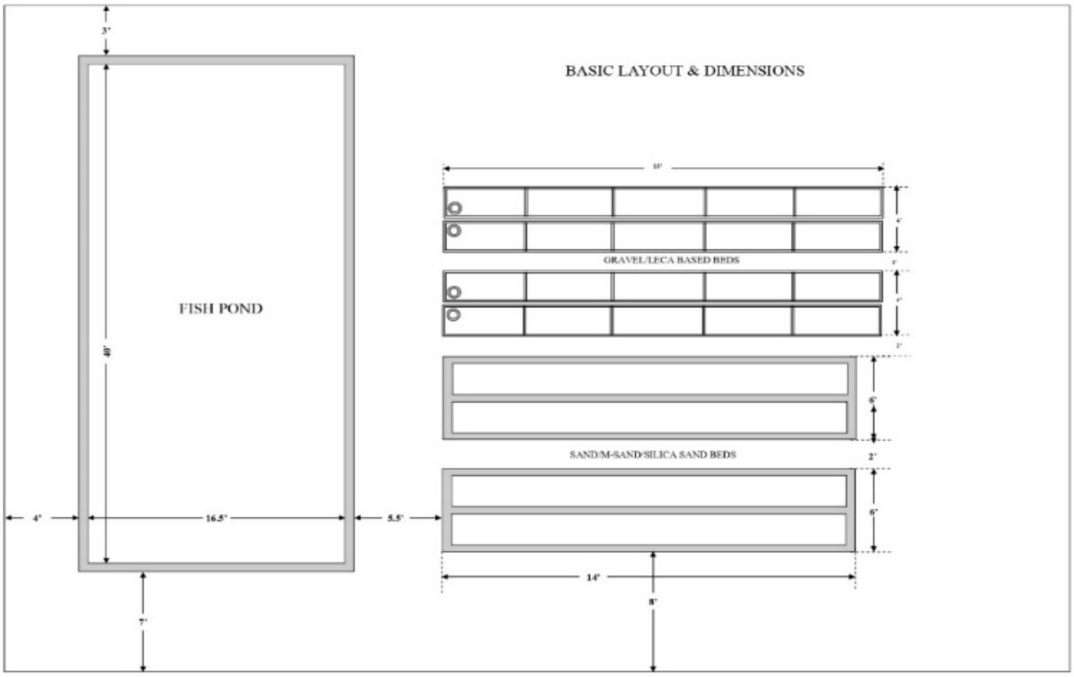
An extent of 0.5 acre (2000 sq m) land would be ideal for establishing a Small-scale Aquaponics Unit to be run on commercial lines. It would essentially comprise of one rectangular fish tank, 10 grow-beds for plants, besides Moving Bed Biofilm Reactor (MBBR) and Filtration Units, Pumps, Aerators, etc. The approximate capital cost would be about Rs. 3.7 lakh and operational costs Rs. 4.1 lakh (total Rs. 7.8 lakh).

The technical details, design and layout, probable project cost, and estimated project costs and returns are given below:

A. Technical Details (Indicative)

Particulars	Details
Fish Culture Tank	
Tank Size & Volume	12 x 5 x 2 m (120 m^3)
Effective Water Volume	100 m^3
Vegetable Growing Beds	
Individual bed size & volume	6 x 2 x 1 ft (12 ft^3) (340 L)
Depth of the bed	0.3 m
Volume of LECA/bed (2 nos.)	150 L/ bed
Quantity of gravel/bed (4 nos.)	150 kg/bed
Quantity of sand/bed (2 nos.)	150 kg/bed
Volume of water/bed (2 nos.)	500 L/bed
Water Filters, Pumps, Aerators, etc.	
Moving Bed Biofilm Reactor & Filter Set	Two Units
Pumps required (2 nos.)	15/18000 LPH
Water flow rate	30/36000 LPH
Aerator (3 nos.)	120 LPM
Auto Timer (1 no.)	20 min.
Fish Species	Tilapia/ Pangassius/ Koi Carps, etc.
Source of Fish	Registered Fish Hatchery/ Seed Farm
Stocking size	Fingerlings (minimum 5 g)
Stocking density	50-60/m^3 (5000-6000 nos.)
Fish Culture period	6 months
Composition of fish feed	28% protein
Type of fish feed	Pelleted feed
Expected weight gain per fish in 6 months	Avg. 500 g
Expected Survival	90% (4500 – 5400 nos.)
Expected Yield/yr	5400 kg/yr
Plant Varieties	Tomato, Mint, Chilly, Lettuce, Basil, Capsicum
Planting Density	15 – 20 saplings/ bed
Total no. of Plant	150-200 plants
Plant Cultivation period	12 months
Harvest type	Partial Harvest

B. Design and Layout (Representative)



C. Probable Unit Costs

Sl.No.	Particulars	Unit Price (Rs.)	Qty.	Total Cost (Rs.)
A	**Capital Cost**			
1	Fish Tank Construction (12 x 5 x 2 m)	1,00,000	1	1,00,000
2	MBBR & Filtration Units	50000	1	50,000
3	Grow-beds for vegetables	70000	1	70,000
4	Coarse sand & ¾" gravel for grow-beds	12000	1	12,000
5	Fish Tank Pump 15000 LPH	9000	1	9,000
6	Air-oxy tube (m)	200	10	2,000
7	Aerators (for Oxygen supply) 120 LPM	10000	3	30000
8	2 KVA solar inverter for power backup	40000	1	40,000
9	Biosecurity fencing for fish tank	20000	1	20,000
10	Plumbing items	30000	1	30,000
	Sub-Total A			**3,63,000**

Sl.No.	Particulars	Unit Price (Rs.)	Qty.	Total Cost (Rs.)
B	**Operational Cost**			
1	Tilapia seed (annually 2 cycles)	5	12000	60,000
2	Feed cost (annually 2 cycles)	35	8500	2,97,500
3	Horticulture sapling	3	1000	3,000
4	Electricity cost (units consumed x cost per unit) per annum (2 cycles)	10	5400	54,000
	Sub-Total B			**4,14,500**
C			**Total (A+B)**	**7,77,500**

D. Estimated Project Costs & Returns

Sl. No.	Particulars	Amount/Quantity
1	Culture period for fish (months)	6 months each crop, total 2 crops
2	Fish fingerlings stocked (nos.)	6,000 nos.
3	Expected Survival	90%
4	Total Fish survived (nos.)	5400 nos.
5	Average harvest size (g)	750 g
6	Expected Production (kg/crop)	5400 nos. x 750 = 4050 kg
7	Total Production per year (2 crops)	4050 kg x 2 = 8100 kg
8	Sale price of fresh/ live fish (Rs/kg)	Rs. 150
9	**Gross Income Per Year** (Rs)	
	From Fish (8100 kg x Rs.150)	12,15,000
	From Vegetables (Rs.)	73,300
	Total Income **(D)** (Rs.)	12,88,300
10	**Net Profit/Year (D-C)** (Rs.)	5,10,800

6. Project Monitoring Unit (PMU)

A Project Monitoring Unit (PMU) comprising representative of the Designated Technology/ Service Provider, Dept. of Fisheries of the State Govt. and the NFDB would be constituted to monitor the implementation and progress of the Project.

7. Further Reading

Christopher Somerville, Moti Cohen, Edoardo Pantanella, Austin Stankus and Alessandro Lovatelli, 2014. "*Small-scale aquaponic food production – Integrated fish and plant farming*". FAO Fisheries and Aquaculture Technical Paper 589, 2014, pp 288.

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System for Urban, Suburban and Rural Settings. NFDB Newsletter *Matsya Bharat*, Vol. 8, Issue 5, January-March 2017, pages 5-15.