Department of Agriculture, Trade and Consumer Protection

Division of Agricultural Development

Agricultural Development & Diversification Program (ADD)

Grant Project Final Report

Contract Number: 18056

Grant Project Title: Multi-season Farming Technologies and Training

Amount of Funding Awarded: $15,000

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Final Report to the WI DATCP ADD PROGRAM:

In this project we had hoped to demonstrate the feasibility of utilizing complimentary indoor and outdoor growing systems for the year-round production of vegetables.

We assembled a variety of aquaponic systems to achieve this goal. These systems consisted of raceways or tanks for the raising of fish (Tilapia), or nutrient-flow tanks utilizing a fertilizer solution composed of leachings from our vermi-culture systems, combined with elevated growing beds for the production of vegetables.

We utilized the talents of our revolving pool of interns as well as our staff's own experience, to document growing methodology and quantify the consumption/production ratio in determining system viability, both biologically and economically.

We provided outreach to consumers through distribution of products by The Milwaukee Small Farmer Distribution Center. During the grant period we raised a large assortment of vegetables, herbs and bedding plants. These plants were raised for our own production needs as well as those of our cooperative members. These products found their way into the retail market in a variety of ways. Reaction to these new products was overwhelmingly positive and they contributed enormously to the income flow of our organization.

Through our many workshops and organized tours we were able to present the results of this grant project to a large audience of Wisconsin's organic and sustainable agriculture community. This outreach is ongoing and being very well received.

We began by using our workshops as a sounding board to determine the best use of our resources. Our training and outreach spanned from our Growing Power Youth Corp to two University of Wisconsin-Madison interns. Using the grant money we then came up with a plan for building a series of new aquaponic systems which would demonstrate the feasibility of using such systems for multi-season production of vegetables.

We implemented what we had learned during these workshops to Train our interns, which in turn, led to the construction of two identical aquaponic systems and the completion of a large-scale nutrient-cycling system. These achievements paved the way for future aquaponic training, broader outreach, and opportunities for quantifying production, cost and functionalities of specific inputs for the aquaponic systems.

We also trained all fifteen members of our Growing Power Youth Corps so that they may participate in training others about the aquaponic and vermiculture systems. This initial training set the foundation for the workshops they conducted during the RIC (Rooted in Community) Conference, an annual youth leadership conference in sustainable agriculture which we hosted in July of 2003. These workshops were attended by over 200 youth from Milwaukee and all over the country.

During the fall and winter of 2003, we worked exclusively on improving our training, outreach and documentation for our aquaponic systems. At the same time we continued to grow healthy produce which was made available to local residents.

In November we held a weekend-long hands-on workshop exclusively for Wisconsin and neighboring farms. We continued to train our youth corps which fruitfully led to many impressive smaller projects and individual achievements for it's members.

Also, during this period, we created written materials for our workshops and began experimentation on the two identical aquaponic systems built in the fall. We created a prototype aquaponic system which we now use during our hands-on workshops. This model has proven so successful that we have been asked to build identical systems for other organizations so that they may teach others.

Beginning in January of 2004, we held monthly workshops in aquaponic systems, vermi-composting, soil remediation, community project planning, marketing and community gardening. Through these monthly workshops we have educated hundreds of people in sustainable food production. When we are not educating others we are improving the methods in which we grow food.

This culminated in the construction of a newly designed large-scale aquaponic system, which currently holds 4,000 tilapia fish. This system incorporates many features from previously built systems as well as new technology. It has automatic water leveling, an energy-efficient 2400 gallon per hour pump and a unique, yet simple filtration system. The feasibility of this system is demonstrated in low maintenance requirements and the equally low mortality rate of it's inhabitants.

We feel that the results of this project were over-whelmingly positive. There were very few missteps, and the systems we built continue to do well. We were able to keep all nine of our interns involved in the process. Several of whom are still in regular contact with us. One of whom continued to work here as a full-time employee, after her internship expired, as a direct result of this project.

We have initiated aquaponic projects in several other cities, with other agencies and organizations as a result of this project. Our work has inspired others to plan aquaponic projects of their own.

We have utilized the products we have grown in our new systems in our Market Basket Program and our weekly farmers market. The efficiencies we were able to establish as a result of our work in aquaponics has resulted in fewer hours devoted to menial tasks such as watering, and more hours devoted to education and research.

We did face several constraints in this project, some of which we were able to overcome, some are works in progress, and others remain to be resolved.

The systems we built were designed around our existing facilities. This meant that electrical outlets weren't always where we would want them. Plumbing had to be re-routed and designs changed. This resulted in un-expected expenditures.

Heating and energy consumption were and continue to be major concerns.
We are in the process of re-glazing our greenhouses, which should help considerably. Re-glazing should also result in enhanced lighting which, in turn, should lead to greater crop yields.

The water heaters, which form the basis of our aquaponic heating systems, could be used more efficiently as well. This is an area where we continue to do research to refine our systems.

The gravel bed filtration system in our new aquaponic system seems to be aging prematurely. This may be the result of our using a commercial food-which contains fillers- to establish our tilapia fry. It could rectify itself as we switch over to more natural foods. In the mean time it continues to be an area of increased maintenance for us.

As we have added features to our new aquaponic system the necessary piping has decreased the pumping capacity of the new pump to the extent that it may have to be replaced with a pump of greater capacity soon. The alternative to this would be to reroute the plumbing again to remove some of the bends and angles in the plumbing of this system.

The two-component systems our interns built for doing comparative studies were placed in such a way that one receives more lighting than the other. This was made necessary by the space we had available to build them. This difference, while slight, remains a concern.

The one variable that did become evident as these systems have been running was that the drain pipe on the system with fish remained un-clogged as a result of their scavenging, while the drain pipe on the system without fish was clogging continually. Our systems were designed in such a way that overflows were avoided. We have since added fish to this system.

In the future we plan on expanding the new aquaponic system in greenhouse two. This greenhouse will become our first devoted completely to aquaponic systems. We continue to develop printed teaching aides featuring the advances we made in design and operation of our systems. These new publications are used in our workshops and shared with all interested parties. We continue to experiment with different vegetables and herbs in a quest to find the most efficient use of our different aquaponic systems.

Requests for assistance in designing aquaponic systems from other organizations continue to literally flood in, resulting in greater recognition and prestige for Growing Power Inc. This increased visibility has enabled us to continue plans for expansion.

We feel that this grant was well worth our efforts. It could easily serve as a model for projects other organizations who are interested in expanding might pursue. We have shown that the systems we designed and built are not only feasible, but worthwhile in terms of increased production and profitability.

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Lesson Plan: Aquaponics Mini Model
Goal: To build and maintain an Aquaponics system

Materials: frame posts (untreated 2x4s)), bed material (plywood, pressboard, scrap wood), PVC piping, pump, tank (minimum 10 gallon), 2 ½" wood screws

Activity 1: Beginning Aquaponics

Time: 15 minutes
Participants will discuss the definition and function of an Aquaponics system, considerations before starting a system, and view and compare the existing systems in the greenhouses
.
What is Aquaponics: The combination of intensive aquaculture (fish farming) and alternative hydroponics. Fish consume food within the system and excrete waste. The beneficial bacteria within the system convert the waste to nitrate which is used by plants completing the cycling of nutrients.

1. Considerations before starting
    a. What are the goals of the system?
        i. Urban food production
        ii. Educational tool
        iii. Construction project
        iv. Individual/ community self-sufficiency
    b. Where will the system be built?
        i. Outdoor protection and heating
        ii. Access to water, electricity
    c. Do you have the necessary resources?
        i. Wood: lumber, plywood, scrapwood, desk drawers, old bed frames
        ii. Lighting: natural light, grow lights, fluorescent lights
        iii. Electricity: for pump, fans, thermometers
    d. Who will maintain the system?
        i. Community members, volunteers, staff, youth, individual
2. Suitable Fish
    a. Tilapia, large mouth bass, sunfish, bream, crappie, koi, carp, pacu, red claw lobster or crayfish
3. Suitable Plants
    a. Leafy lettuce, pak choi, spinach, arugula, basil, mint, watercress, chives, most houseplants, tomatoes, peppers, cucumbers, beans, peas, squash

Activity 2: Building a System

Time: 1 hour

Participants will build a low-cost system as a group

1. Clear the workspace and area for Aquaponics system. Set-up horses and work table.
2. Gather the materials for construction and review a drawing of the Growing Power model tank and shelf system.
3. Make sure all of the materials are the appropriate size/dimension. If not, cut lumber and PVC piping to right size.
4. Build the frame
    a. Determine which two posts will be nearest the fish tank and mark them. Place the other two posts approximately four feet away, creating a rectangular space.
    b. Decide on the height difference between the middle and top growing beds, 2 feet works well. Mark the middle bed two feet from the ground and the top bed two feet from the middle bed.

        - when you mark the middle and top beds make sure you create a ½" difference in height from the tank-end to the other end (the slope of the bed will be ½" to allow water to flow with gravity).

    c. Using bolts, washers, and nuts connect the four posts with the Bed supporting 4' long 2"x4"s. There will be three on each side. Match the upper side of the board with the markings on the frame. Two of these side supports will serve as bed supports (the top and the middle side supports) so make sure they are on the inside of the frame.
    d. Connect the two sides with the shorter frame supports (the 3'4" long 2"x4"), finishing the building of the frame. These supports may go in-between the middle and the bottom bed on the outside of the frame.
    e. Once all of the pieces are attached, straighten the frame and tighten all of the nuts.
5. Build the beds
    a. Nail or screw the bottoms to the sides, leaving one side open where the water will exit.
    b. Staple the plastic onto the bed to create a watertight "trough." Make sure you staple the plastic to the outside of the bed.
    c. Place the beds on top of the groove in the shelf frame.
6. Tank set-up
    a. Drill a hole in the tank the size of the PVC coupling (this part can be tricky, make sure the diameter of the hole is the same as the male piece of the coupling that will go through the hole).
    b. Attach the PVC coupling with the male end inside the tank.
        i. The fit should be tight, use PVC primer, cement, and silicone to create a seal if the structure will be permanent.
    c. Put together "S-shaped" pipe (piping where water leaves the tank) – depending on height of bottom bed and height of tank, make the s-shaped piece higher than the bottom bed but lower than the tank (as low as possible).
        i. The "S-shaped" piece consists of 2 90º PVC elbows, 4 pieces of 6" long PVC, and one valve. The size of the PVC depends on how fast you want the water to flow out of the tank AND how big the coupling is you are attaching the "S-shaped" piece to.

            *for permanent structure use PVC primer and cement to seal the s-shaped piece together. Use silicone to waterproof the connection.

    d. Place a piece of ¼" metal grating over the inside opening to keep fish from going through the PVC piping.
7. Pump set-up

   a. Connect the sump pump sewer hose (1 ¼ “) to the pump using a wire ring. It may be necessary to use a PVC piece to adapt the pump opening to the hose.
   b. Using another wire ring, connect the “L-shaped” PVC piece to the other end of the hose. This pieces consists of one 90° PVC piece, 2.5' long PVC, and a cap at the end of the PVC pipe.
8. Check all the connections for a watertight fit.
9. Add water to the tank and bottom bed first. Once the pump is submerged, turn the pump on and observe the water flow. Make sure there is consistent water flow, that the pump remains submerged, the water flows into tank from the bed, check for leaks, and make sure the tank does not overflow.

*this last part may take a little longer for the system to check and balance itself.

AQUAPONICS MATERIALS LIST

LUMBER (untreated):

	Quantity	Size/dimension
Posts:	**6**	**4"x 4"x 8'**
Bed sides, Bed supports:	**16**	**2"x 6"x 12'**
- Top, Middle, and Bottom bed sides; Bed supports:	12	2"x 6"x 12'
- Top and Middle Bed back sides; Bottom back and front side:	6	2"x 6"x 4'4"
- Top and Middle Bed front sides:	4	2"x 6"x 1'8"
Bed cross support pieces:	**7**	**2"x 4"x 8'**
- Top, Middle, and Bottom Bed cross supports:	14	2"x 4"x 4'
Frame cross support:	**3**	**2"x 4"x 10'**
- Frame and Post cross supports:	5	2"x 4"x 4'4"

PLYWOOD (¾ " exterior plywood):

Top, Middle, and Bottom beds (and Bottom bed sides):	**7**	**4'x 8' sheets**
- Bottom side of Top, Middle, and Bottom beds	3	4'x 8'
	3	4'x 4'
- Bottom bed Sides:	4	2'x 4'
	2	2'x 8'

PVC “plumbing” (if there is a 200 gal. tank):

1 pump
1 1 ¼ " sump pump hose
1 PVC adapter for pump and hose
4 wire rings (make sure the range will fit a 1" pipe)
3 1" T PVC pieces (they are unthreaded T-shaped PVC pipe connectors)
4 1.5' long 1" PVC pieces
4 1" PVC slip-on caps
2 90º 2" PVC elbows
1 6' of 2" PVC (to be cut into the pieces necessary for the “S-shaped” piece)
1 female and male coupling (2" PVC)
1 2" PVC ball valve
1 2' deep and about 2' diameter plastic tub
(this holds the pump in place inside of the filtering bed)
PVC cement and PVC primer (OR PVC tape)
1 tube of clear silicone (optional, use if there are leaks from tank)

HARDWARE:

Staples
3" screws (and drill bit)
2 ½ " screws

MISCELLANEOUS:

Aquarium tank needs (air stone, thermometer, heater)
Lava rock (enough to fill bottom bed about 1/3 of the way)
4 55 gal. drums OR 200 gallon tank (PVC requirements change depending upon tank type)
6 cinderblocks
1 8"x 8" metal screen (½" metal screen)
6 90º metal elbow plaques (used to connect two pieces of lumber at a 90º)
cloth rags
~ 10 feet of rain gutter (or something similar to channel water)

TOOLS (IF all of the wood is precut, we will not need a power saw):

Horses
Power drill (make sure the screwdriver bits match up with the screws)
Staple gun
Straight line chalk
Power saw
Drill bits to make holes for the screws (check with the size of the screw)
Measuring tape
Safety glasses
Scissors
Extension cord

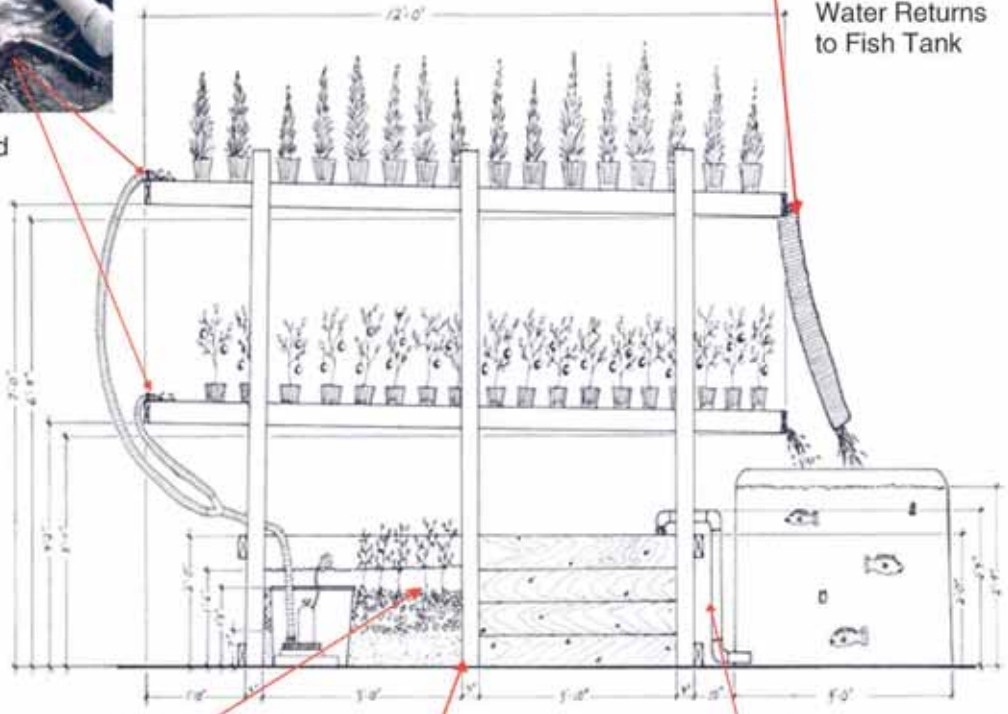
Aquaponics System Schematics

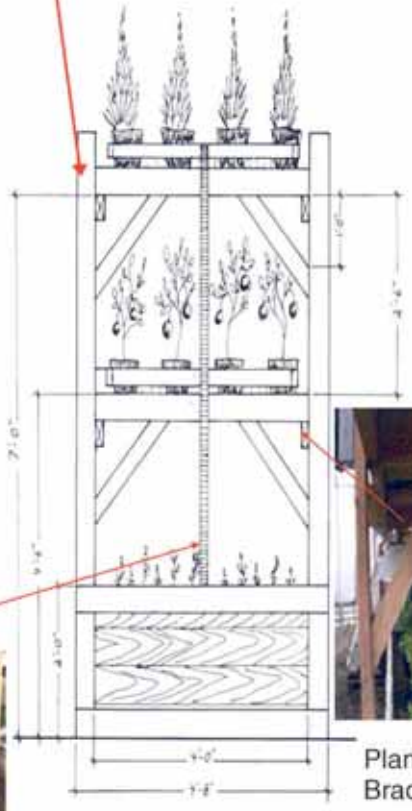
Water Returns to Fish Tank

Bed and Post Construction

Planting Bed Watering

Long View of System





Planting Bed Brace

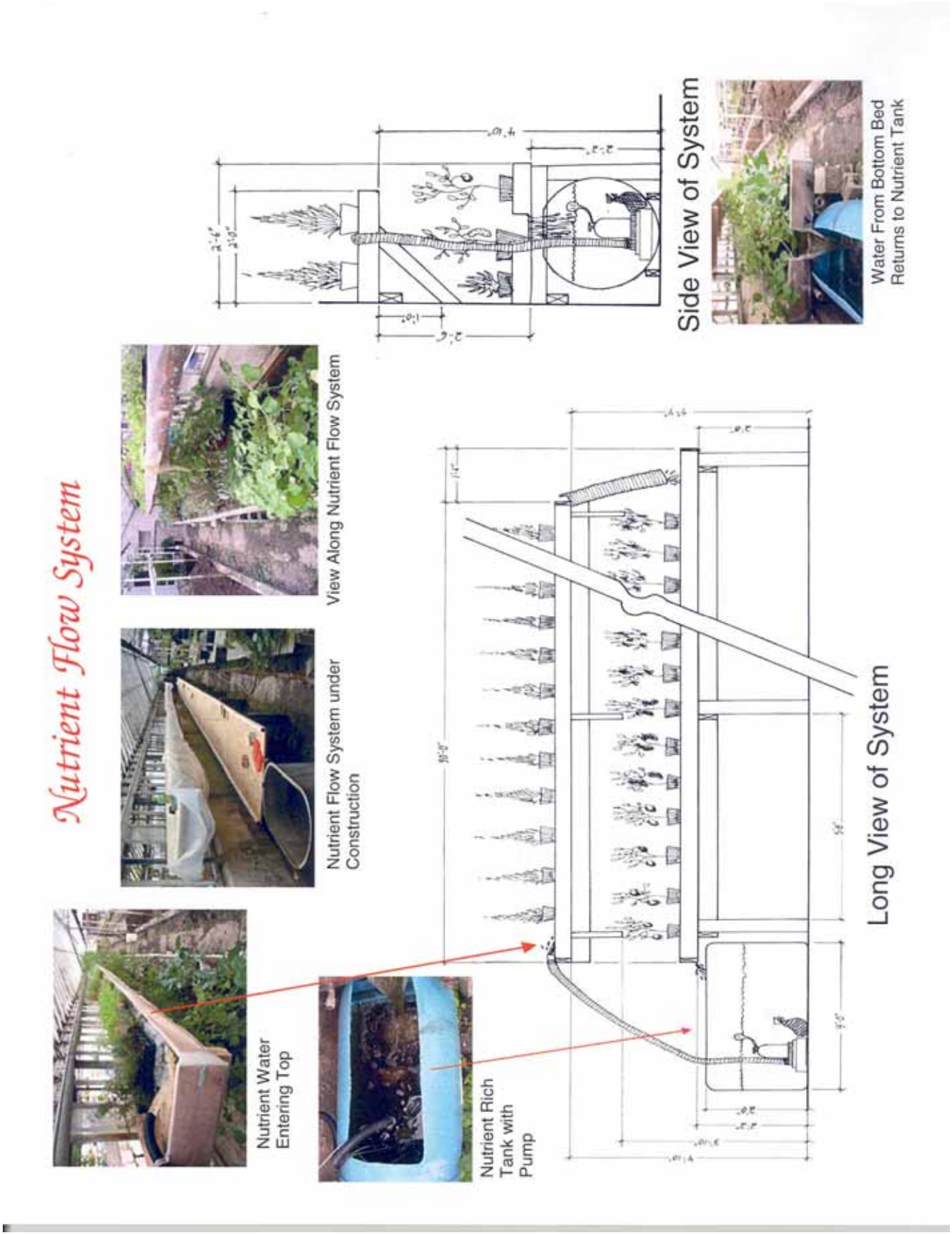
Filter Bed Plants

Post & Bed Construction

Fish Tank Water Pumped to Lower Bed

Hoses From Pump to Beds

Side View of System


Nutrient Flow System
Nutrient Water Entering Top
Nutrient Flow System under Construction
View Along Nutrient Flow System
Nutrient Rich Tank with Pump
Long View of System
Side View of System
Water From Bottom Bed Returns to Nutrient Tank

Step 1: DISCUSSION

In my experience working with low-tech Aquaponic systems, I can assure you anyone is capable of designing, allocating construction materials, constructing, maintaining, and educating others on how to build an Aquaponics system. The process may appear difficult and complex, but once you get comfortable with the idea of building a system and experiencing what it takes to build a mini-model (which you will do today), the rest will seem simple. All you need is the desire and confidence to want an Aquaponics system and the rest will follow. Here are a few questions to discuss prior to building a mini Aquaponics system:

a) What is the purpose of the system? What are the goals of building/maintaining an Aquaponics system?

Urban food production, educational, construction skills, learning resourcefulness, a new challenge, catalyst for self/community empowerment . . .

b) Where will the system be built?

Inside, outside, open spaces, windows, air circulation, drains, nearby water source (is it connected to city water, electrical outlets, sturdiness of floor –if above ground floor

c) Do we have the resources to build the system we design?

Think of resources such as construction materials (lumber, plywood, scrap wood, desk drawers, old bed frames . . . be creative), lighting (growing lights or fluorescent lights), water source, electricity (pumps, fans, thermometers), piping, tank

d) Once the system is built, who will maintain it? Who will continue to pass on the knowledge of Aquaponics construction and maintenance?

Community members, volunteers, Organizational staff, Youth group, Individual

Step 2: PRE-CONSTRUCTION

a) Go over materials used for building a mini Aquaponics system -compare to larger system.

PARTS:

Frame: Posts----------4 pieces of 6 foot long 2in.x 4in. untreated wood
Supports (length)---4 pieces of 4 foot long 2in.x 4in. untreated wood
(width)---4 pieces of 3 foot 4 in. long 2in.x 4in. untreated wood
Bed rests----------4 pieces of 4 foot long 2in.x 4in. untreated wood

*Use two 2 ½ in. screws (model uses bolts) for every joint in frame (it helps to drill holes prior to putting in screws . . . make sure your drill bit is the same diameter as your screw, if not the same, it should be smaller).

Beds

Pump and piping

Tank

b) Clear working area space

c) Set-up horses for sawing area

Step 3: CONSTRUCTION

a) Build frame

1. Determine which two posts will be nearer the tank. Mark the posts accordingly (decide how high off the ground you want the middle and top bed, we recommend about two feet in-between beds
2. Mark the two farther away posts (you only need ½ in. difference in height from tank-side post to farther away post to create an angle in the bed allowing for water run-off). *If the top bed is going to empty into the middle bed remember that the slopes will be angled in opposite directions!

b) Build Beds

1. Nail or screw bottoms to sides (leave one side open . . . that's where the water will exit bed)
2. Staple on plastic (we recommend 12mil. black plastic)
3. Place beds on top of proper groove

c) Set-up tank system

1. If there isn't already a hole in the tank, drill a hole using a circular drill bit with the diameter of your PVC coupling
2. Hook-up the PVC coupling (the male piece goes through the hole from the inside of the tank so that it sticks out the other end where the female piece can screw onto it).

*make sure the PVC coupling is tight (if permanent structure, use PVC primer and cement to seal coupling and then silicone seal the PVC coupling on both sides to the tank and let sit for 24 hrs.

3. Put together "S-shaped" pipe (piping where water leaves the tank) – depending on height of bottom bed and height of tank, make the s-shaped piece higher than the bottom bed but lower than the tank (as low as possible).

*Don't forget your valve (for permanent structure use PVC primer and cement to seal the s-shaped piece together

4. Put a ¼ or ½ inch metal mesh over the inside opening of the tank (this prevents fish from swimming through the hole).
5. Connect the S-shaped pipe to the tank (once again, use PVC primer and cement for a permanent seal)

d) Set-up pump and piping system (this part can be tricky, just be patient with finding the right pieces to connect everything together)

1. Connect sump-pump sewer hose (1 ¼ inch sewer hose) to the pump using a wire ring and PVC coupling if necessary

* If a permanent systemDepending on preference, use a continuous flow pump or a pump with a floating detector (if you are suing the latter, i

e) Check all the connections

<u>Tid-bits:</u>

-*Research different systems and plants*

-*listen and learn from other's experiences*