Adapting Outdoor Aquaponics Systems to Seasonal Locations

The University of Michigan Food Industry Student Association (FISA) is a student organization dedicated to helping its members explore career opportunities in the food industry. The aquaponics design team, a part of FISA, is interested in using aquaponics to provide affordable fresh food to people in food deserts in Southeast Michigan.

In order to address this issue, we have identified two main goals for our project. First, we want to develop an outdoor aquaponics system capable of remaining productive during the winter months, for which there are not yet systems available. Second, FISA plans to work with residents in Southeastern Michigan in order to help them implement their own aquaponics systems. In line with these goals, our project is divided into two phases, development of the aquaponics systems and collaboration with Neighborhood B.U.G., an organization dedicated to reducing hunger in Detroit.

Background: Common Aquaponics Systems

Aquaponics is a form of small-scale, sustainable urban agriculture that combines hydroponics and aquaculture. Fish in the aquaculture produce ammonia, which is then pumped to the biofilter and converted to nitrates for the plants. This process feeds the plants and removes toxic ammonia from the fish’s’ water; the system consumes the waste it produces. Compared to a typical fish farm, recirculating aquaculture systems can reduce land use by a factor of 77 and water use by a factor of 420.[1]

What makes aquaponics difficult to pursue commercially is the high initial investment required and the long payback period. For less experienced farmers the start-up can be particularly frustrating. In addition, there is large costs associated with heating and lighting, particularly in the Midwest winter.

To address the cost of an outdoor aquaponics system, one common solution is to build the garden indoors and use grow lights instead of sunlight. However, the farmer would need to own/lease an indoor space large enough for the capacity they want to produce and buy enough grow lights to cover every square foot of planting area (>30/ft²).[3]

Phase I: Prototype Aquaponics System

Our solution to address the prohibitive indoor start-up cost is to use an outdoor garden capable of surviving the winter. To reduce power consumption during the winter, our plan is to temporarily shrink our model 500 gallon system into the 225 gallon fish tank unit, with the fish and plant rafts segregated inside. With a substantial amount of insulation, the fish tank can stay above 60°F with less than 0.3 kW of electrical heating. While this design has a smaller production capacity, it is able to maintain the bacteria culture, meaning that less time is spent bringing the system back to full capacity and larger scale growing can begin immediately once temperatures permit. The small capacity is further justified by the over $1000/year saved on heating. Also, the fish experience less stress since they will not need to be transferred out of the tank, and the associated cost of moving and potentially replacing fish is minimized.

We are also researching ways to integrate vermiculture (i.e. worms) into our design. We plan to design and build a heat exchanger that recovers the energy generated by aerobic compost bacteria living in vermicompost in order to control the water temperature of our garden. This will help expand our full capacity grow season even further into the cold months.

The main specifications of our garden are as follows:

- Be able to grow 46 heads of lettuce at full capacity and 12 heads during the winter
- Be able to hold 20-30 bluegill fish
• Have a construction cost less than $800 and an utility cost less than $200

**Phase II: Collaboration with Neighborhood B.U.G.**

Neighborhood B.U.G. is a non-profit organization that “provide[s] training, resources and support for growing food and jobs”[4] for disadvantaged black communities in Detroit that are considered food deserts. This organization has had success in the past turning an abandoned lot into a community garden and training families in the art of aquaponics with small scale aquaponic growing kits. Neighborhood B.U.G. is looking to expand their mission and has recently purchased five more lots and an abandoned home (all congregated on the same street[5]) in Detroit that will be transformed into a hands-on gardening education center. These spaces will be used for practice in a variety of gardening techniques including aquaponics, vermiculture, beekeeping, and traditional gardening.

We plan to construct our model community aquaponics system in a Neighborhood B.U.G. lot (see APPENDIX for pictures), and to provide hands-on learning for Detroiter in construction and operation of their own aquaponics systems through existing programs and classes that Neighborhood B.U.G. is already holding. While our garden in Ann Arbor will be used to research the economic and technical merits of our design, the garden in Detroit will be used to test if the people of the community take interest in the design/find it useful. If our design is successful on these fronts, we will seek to expand our design to more neighborhoods in the second round of the Dow competition.

**Budget**

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<th>Item</th>
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<tr>
<td>Construction Materials:</td>
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<tr>
<td>Utilities through this and next winter (7 months):</td>
<td>$370</td>
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<tr>
<td>Summer Caretaking/Gardening Expenses</td>
<td>$800</td>
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<tr>
<td>Volunteer Trips to and from Detroit</td>
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<tr>
<td>Total</td>
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**Schedule**

- **April 2016:**
  - Perfection of winterization technology
  - Expanding garden to outdoor grow bed, introduction of new fish
  - Begin volunteering with Neighborhood B.U.G. to develop their empty lots
  - Begin to assist with Neighborhood B.U.G.’s educational programs
- **May-September 2016:**
  - Full-capacity operation, construction and testing of vermiculture heater
- **Oct.2016-Mar.2017:**
  - Install our aquaponics system at Neighborhood B.U.G.’s location

**Our Team**

Joseph Trumpey, Associate Professor, School of Art and Design, Faculty Advisor
Emily Canosa, UM Sustainable Foods Program Manager
Emma Hyde, Industrial Operations Engineering, Aquaponics Project co-Lead
Haley Evans, School of Art and Design, co-lead of UM Permaculture Design Team
Maddie Baroli, Program in the Environment, LSA, co-lead of UM Permaculture Design Team
Michael Downs, Program in the Environment with specialization in Aquatics/Fish, LSA
Michael Meldrum, Chemical Engineering, Aquaponics Project co-Lead
Stuart Nath, Chemical Engineering, Point of contact for Dow Distinguished Awards
APPENDIX

Site of Neighborhood B.U.G. Gardens

Site of Future Aquaponics System

Footnotes


[3] Based on rule-of-thumb of 25 watts for every square foot of growing area, and we estimated the price to be ~$30/25 watts based on the prices of 25 watt units.


[5] 14616 Monica, Detroit, MI 48238