Farming to Extinction:
Increase Funding for Aquaponics Research

By Rachel Baker

Introduction

The United States Census Bureau estimates there are over 7 billion people in the world today. While every one of us has different beliefs and goals and may live on the other side of the globe, we all need the same three things: clean air, water, and food. But all three of these basic human needs are quickly disappearing.

Our current agricultural and fishery systems contaminate our drinking water, decimate wild life populations, and are running out of room. Currently, projects are underway to modify our food to create hardier, healthier, and larger produce and fish. But I propose that there is an already successfully tested solution; we've just forgotten about it.

Ancient Aztec and Asian civilizations practiced a method of farming combining soil-less plant cultivation with fish to create a symbiotic and low maintenance ecosystem. Today, urban farmers have taken that idea and modified it for their rooftops, backyards, and neighborhood gardens. With added funding, this practice, called aquaponics, could be studied and engineered to be a sustainable replacement for our current agricultural system.

Background

More than 40% of the world population lives more than 100 km away from the coast; while others, like Saudi Arabia and Gaza, have access to ocean coastline but have limited freshwater, which puts pressure on the coastal ecosystems to provide enough food. Instead, people have begun to rely on farm-raised fish, or aquaculture.

Aquaculture makes up 47% (51 million tons) of the world's fish consumption with a projected increase in 2015 to 74 million tons. 68% of all aquaculture is produced in freshwater, using local ponds, lakes, canals, or tanks, which often excludes coastal countries from due to their lack of freshwater. As of 2008, the United Nations Food and Agricultural Organization recorded that 88% of all production is found in Asia (Klinger 249). Aquaculture provides affordable access to fresh seafood and income from sales for developing countries. In 2008, "10.8 million people relied on aquaculture as a source of income and livelihood" (Klinger 249).

"More than 3.5 billion people depend on the ocean for their primary source of food" (Oken). Fish are highly digestible and are a source for high-quality protein with essential amino acids that our bodies cannot make on their own. Omega-3 fatty acids, found in salmon, can improve infant brain development and protect against heart disease and stroke (Oken).

In a perfect world, aquaculture has the ability to feed billions of people, but, due to many factors like high demand and inefficient systems, farm-raised fish pose numerous environmental issues.

- **Aquaculture systems use a large amount of freshwater.**
- **Often water leaches into groundwater and aquifers causing salinization.**
- **Juvenile wild fish are overfished to stock operations.**
- **Overfish wild populations to create meal and oil for captive fish.**
- **Fisheries leach toxic pollutants into surrounding ecosystems.**
  Uneaten food, excrement, antibiotics, and other chemicals leach from the tanks, open ocean cages, or pond reservoirs into the surrounding water and groundwater. Materials used to create many open ocean cages can leach heavy metals. Generally, on a daily basis, aquaculture systems discharge contaminated water and replace it with fresh water "at 5% to 10% of recirculating water volume" (Tyson 7). "Hites et al. (2004) found high levels of organochlorine contaminants in salmon farms in Scotland, Norway, and eastern North America" and suggested that fish from these areas should not be consumed more than 3 to 6 times annually (Clements). Okomoda cites a report by Gowen in 1992 that stated fish systems in England used 23 kinds of chemicals to prevent diseases and maintain and disinfect the water.

  In areas of the Zhu-jiang Delta, bluestone was used to treat shrimp disease, and the copper from the treatment still pollutes the water years later. Some system use little to no filtration, which allows uneaten solid food and fish excrement to leach into outside water sources. "Funge-Smith studied the material balance in the shrimp pond of [sic] paddy field, and found that only 10% [of Nitrogen] and 7% [of Phosphorous] were utilized in the aquaculture, and others all entered into the environment by various forms" (Okomoda 12). The pollutants create a toxic environment for the native species, which result is population depletion through death and disease. Nitrogen and phosphorous are food sources to multiple algae. The excess feeds algal blooms that block sunlight to underwater vegetation and deplete the oxygen in the water. These algal blooms can also cause a spike in pH, which can stress fish and leave them vulnerable to parasites and toxin poisoning (Nitrogen).

- **Escaped fish transmit disease and compete for recourses.**
  Captive-raised salmon, while an excellent source of omega-3 fatty acids, are notorious for transferring disease to their wild counterparts. Introduction of Atlantic salmon from nets into the Puget Sound and Pacific Northwest rivers and streams. Salmon are carnivores and, once escaped, can disrupt natural ecosystems by eating natural species' prey. Atlantic salmon have been known to compete with the natural Pacific salmon for food and spawning ground, but, due to their previous poor conditions, are often weaker and riddled with disease. Escaped captive-raised fish is the largest cause of sea lice outbreaks in wild salmon and orcas who feed on them. Sea lice are small crustaceans that attach to fish through suction cups and feed on their protective mucus coat and skin, creating lesions, which are deadly to the smaller, juvenile fish (Clements, Okomoda).

Solution

"Traditionally, farming has been a rural enterprise" (Tyson). Our forbearers traveled into the heart of the US to stake out land and create their agricultural empire. Overseas, farming is maintained in isolated areas outside urban cities. However, due to population increases, our urban life is encroaching on our agriculture. Farms are losing land and our cities are being exposed to toxic run-off in the drinking water. Instead our farms need to move in and up. Aquaponics may be the answer.

"Profitable farming systems are especially important for maintaining farming enterprises in peri-urban areas to ensure sufficient domestic food supply" (Tyson 10). As Tyson and all suggest, funding needs to be allocated to finding a profitable and environmentally conscious method of farming. Due to the Farm Bill funding increase in 2008, the USDA's "Know Your Farmer, Know Your Food" initiative offered 20 grant, loan, and support programs, but, since 2000, only $7 million in federal funds has been awarded to aquaponics projects.

"Going green" is on the rise in the United States. There has been an extreme increase in interest for going organic, healthful, and environmentally conscious. Aquaponic systems are efficient and varied. Fish and vegetation can be grown in various locations, like on roofs, in backyards, vertically, suspended, in parks, or in alleys (the possibilities are endless), and growers have multiple options for crops to produce. But how is aquaponics different?

Aquaponics refers to the combination of aquaculture, fish, and hydroponics (soil-less plant farming). The closed system links fish and plants together in a symbiotic environment. The fish live in tanks with filters to remove large debris and circulate the water. As exhibited in Figure 1, tubing attaches trays with plants suspended in water to the fish tanks. The water flows from the fish, through the tube, across the plants roots in the trays, and back to the fish. The plants grow without fertilizers, and, as long as the fish are stocked correctly, they remain healthy and don't require antibiotics.

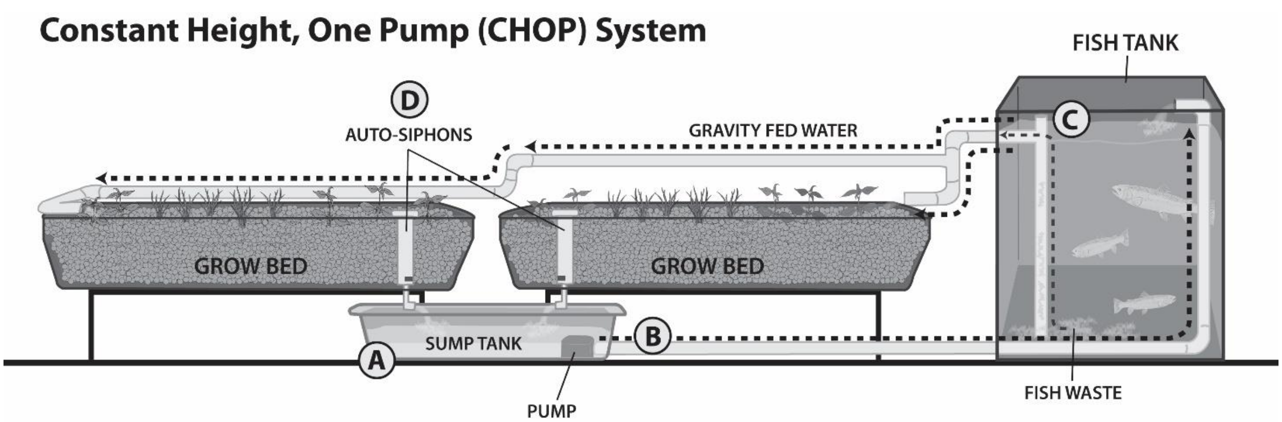

Figure 1: Aquaponic System Map

Multiple types of plants and fish work well in these systems. The following list includes, but is not limited to, the most popular crops:

Plants

- Lettuce
- Herbs
- Spinach
- Basil
- Chives
- Tomatoes
- Bell peppers
- Cucumbers

Fish

- Tilapia
- Carp
- Striped bass
- Goldfish
- Rainbow trout
- Murray cod
- Catfish
- Various crustaceans, like crayfish

As part of the nitrogen cycle, as shown in Figure 2, fish take in food and produce waste in the form of ammonia. Nitrifying bacteria builds up in the filter to break the ammonia down into nitrites, and then nitrates. In a traditional aquaculture system, a percentage of the water would need to be taken out and replaced to remove the nitrates. But in an aquaponic system, the plants take in the extra ammonia, nitrites, and nitrates as nutrients and return the now clean water back to the fish.

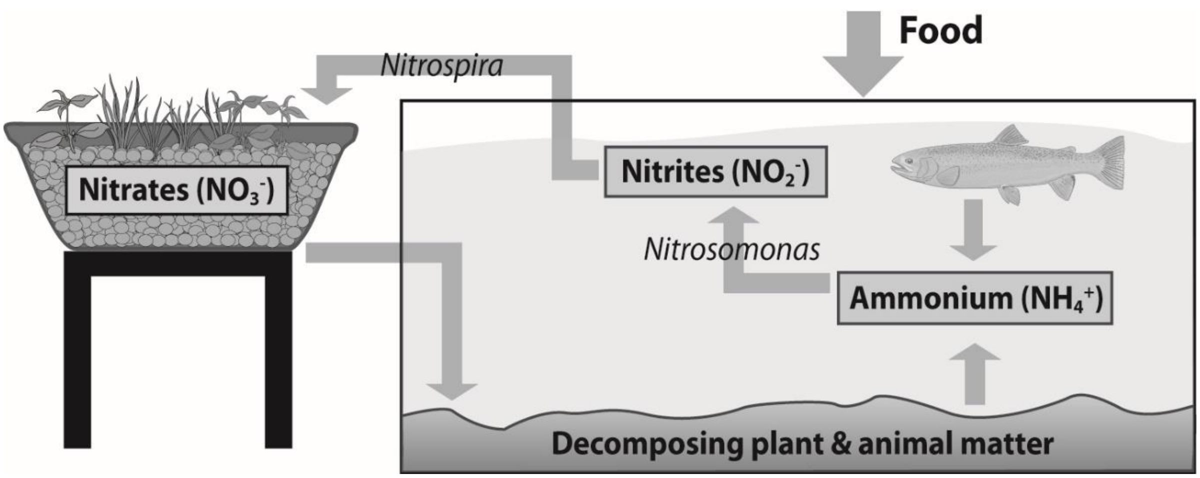

Figure 2: Aquaponics Nitrogen Cycle

Traditional aquaculture systems must remove at least 10% of the contaminated water and replace it with fresh water daily. Vegetable crops like tomato or cucumbers require from .5 to 1.9 L of water per plant per day, depending on the size of the plant. If you assume a plant needs 1.2 L on average, 100 plants could make up the required 5% to 10% of water to be removed in an aquaculture system of 4380 to 8760 L (Tyson 9). Plants act as biofilters, taking up old water, filtering out the nitrites and ammonia for nutrients, and returning clean water back to the fish.

In Gaza, aquaponics is saving lives. During the summer of 2014, the Israeli offensive lasted 51 days and left 2,000 Palestinians dead and tens of thousands of houses damaged or destroyed. It wasn’t safe to go buy vegetables and famers were cut off from their fields. Instead, families took to their roofs to grow their own food. Abu Ahmed was aided by the United Nations Food and Agriculture Organization to create an aquaponics system on his roof. He grows fish, tomatoes, eggplants, and peppers regularly and is able to sustain his family. He hopes that he can add to his system to be able to grow enough produce to sell to others. Since the farmers are unable to get to their crops, produce is scarce and the prices have soared. Other families in Gaza have followed their example.

In Gaza, 90% of water is unfit for drinking, but the aquaponics systems can recycle that water to grow food. Produce can be grown with zero waste, with less than half the water and in a fourth of the space as traditional farming. The only downside for Gaza is the need for electricity to run the filters for the fish. Frequent power cuts make the families go up to the roof and stir the water to keep it properly aerated for the fish. Generators are a luxury that many don’t have.

Many US cities have taken up urban aquaponics. In Chicago, a startup called Greens and Gills is looking to buy property that can house 100,000 pounds of fish and 1.5 million heads of greens per year. A nonprofit organization called Growing Power is creating its own aquaponics system in a former truck depot. Love et al decided to survey numerous aquaponics growers across the US. They found that the most common growers were small and sold to neighbors, at farmers markets, or local whole foods grocery stores. “Results from research facilities and other factors, such as expanding interests in sustainable agriculture and producing food closer to urban centers, have stimulated interest and involvement from a small but growing aquaponics industry.

However, little research has been conducted on commercial-scale aquaponics production” (Love 67).

Gaza and other impoverished nations need further research to be conducted into sustainable aquaponics. The innovations can improve local agricultural practices, but they can also be applied worldwide. Current agricultural practices are destroying our environment. Agriculture is responsible for 20% of greenhouse gas emissions, through fertilizers, machinery, processing plants, and delivery trucks (Sullivan). Fertilizer run-off is contaminating our streams and drinking water. It’s creating algal blooms in rivers and ponds that are killing plants and fish. Aquaponics uses “70% to 90% less energy than conventional or organic farms [sic] which use fuel and/or petrochemical intensive fertilizers” (Why). There is “no soil, weeds, soil pests or pathogens,” (Why) which means that there is “no labor required for tilling, cultivating, fertilizer spreading, compost shredding, manure spreading, plowing cover crops in, or irrigation” (Why). Growers just seed and harvest the bounty.

Conclusion

Aquaponics could be the new alternate food source. With research, alternate energy sources could be created, like solar, wind, or hydroelectric, to make aquaponics systems even more environmentally conscious and easier for farmers like the families in Gaza who don’t have access to constant electricity. The systems can be set up in single layer rows like traditional farming, or they can be stacked to maximize space. Future testing could be done in prisons so prisoners could work to provide their own food and relieve the financial burden on the taxpayers. Non-profits can take aquaponics to Africa and war-torn Middle Eastern countries to provide sustainable food for families and orphanages. Currently, aquaponic systems are bulky and require constant electricity to run efficiently. With funding for research, the systems could be improved and streamlined for home and commercial agriculture.

Works Cited

Clements, Jeff. "A Problematic Solution: The Negative Effects of Aquaculture." Urban Times RSS. N.p., 27 Aug. 2011. Web. 05 Apr. 2015.

Klinger, Dane, and Rosamond Naylor. "Searching for Solutions in Aquaculture: Charting a Sustainable Course." Annual Review of Environment and Resources 37.1 (2012): 247-76. Annual Reviews. Web. 30 Mar. 2015.

Love, David C., Jillian P. Fry, Ximin Li, Elizabeth S. Hill, Laura Genello, Ken Semmens, and Richard E. Fry. "Commercial aquaponics production and profitability: Findings from an international survey." Aquaculture 435 (2015): 67-74. Web. 1 Apr. 2015.

"Nitrogen & Phosphorus." Dead Zones. Chesapeake Bay Foundation, 2010. Web. 01 Apr. 2015.

Oken, Emily. "Seafood Health Benefits & Risks." Seafood Health Benefits & Risks. Harvard School of Public Health, n.d. Web. 01 Apr. 2015.

Okomoda, Victor T. Aquaculture and the Environment, Effects and Best Practices. Rep. N.p.: n.p., 2011. Effects of Aquaculture on Environment. Web. 02 Apr. 2015.

Qandil, Ala. "Rooftop Gardens Provide 'answer for Gaza'" - Al Jazeera English. N.p., 24 Jan. 2015. Web. 28 Mar. 2015.

Sullivan, Rachel. "Local Food for Sustainable Communities." ECOS Magazine. N.p., 2010. Web. 30 Mar. 2015.

Tyson, Richard V., Danielle D. Treadwell, and Eric H. Simmone. "Opportunities and Challenges to Sustainability in Aquaponic Systems." HortTechnology 21.1 (2011): 6-13. Web. 29 Mar. 2015.

"Why Aquaponics?" Green Acre Aquaponics, 2012. Web. 2 Apr. 2015.