Aquaponics: A New Age Solution to Food Insecurity

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Introduction

Food security is defined as having availability and access to sufficient, safe and nutritious food to maintain a healthy and active life. Because of a global population increase, limited space, dwindling resources such as water and soil, and climate change on the horizon, we are on the verge of a global food crisis (Viviano, 2017). Hunger has the potential to be the most pressing and catastrophic issue of the 21st century. Small Island Developing States (SIDS) currently struggle with food security because they import the majority of their food. The Bahamas, an example of a SIDS, has soil made primarily of limestone which is basic and provides little nutrients for plants, making traditional farming methods a non-viable option (The Island School). We need to find a more sustainable means of producing food, which means using less water, space and fossil fuel or else this projected food crisis could become a reality.

Facts:

- A 2.5 billion population increase is expected over the next 30 years (Viviano, 2017).
- At least 1 billion people could face hunger in the near future (Viviano, 2017).
- According to Ernst van den Ende, a leading researcher and the managing director of Wageningen University & Research's plant sciences group, we must produce: "*more food in the next four decades than all farmers in history have harvested over the past 8,000 years*" (Viviano, 2017).
- The Bahamas imports 89% of their food which:
    - Costs approximately $1 billion per year
    - Has a high carbon footprint
    - Is a lower quality (The Island School)
- If cut off from imported food, Eleuthera would last only two weeks before running out of food (The Island School).

What is Aquaponics?

Aquaponics is a great solution for the pending food crisis. Aquaponics is a combination of hydroponics and aquaculture in a recirculating system. Figure 1 outlines the basic process of aquaponics.

Aquaponics is a sustainable method of farming, largely due to these benefits:

- Uses 90% less water than traditional farming
- Reduces environmental impacts due to the recirculating system
- Produces 200% more crops per square foot than traditional farming
- No soil is needed which allows for food production in places with poor soil or cities

Figure 1. *The Aquaponics cycle*

Problem

At the Cape Eleuthera Island School (C.E.I.S.) the aquaponics system has a nursery and broodstock incorporated into its main system. This allows for on-site breeding of tilapia. Because external weather patterns cause changes in temperature that effect tilapia breeding, there is a seasonal gap in system output.

Due to the **geographical location** of the C.E.I.S. system it is impractical and unsustainable to ship fish to Eleuthera. With the current nursery and broodstock system, the issue is that fry (juvenile fish) cannot be produced year-round due to **cold temperatures** in winter (see Figure 3). The optimal temperature for tilapia breeding and growth is 28°C. **Variable temperatures** cause cold shocks leading female tilapia to reabsorb their eggs.

In order to optimize output, these two components must be divided into separate systems. Because tilapia breed at a higher temperature than lettuce, the main crop of this system, it is crucial that only the nursery be heated. With fry being produced all year-round there will be no gaps in the systems production.

Research Question:

Is it possible to separate the nursery and broodstock from the main system and maintain a consistent 28 ℃?

Methods

1. Engineering Design Process
    a) Analyzing the problem
    b) Finding viable solution
2. Preliminary Calculations
    a) Calculating flow rates
    b) Measuring existing tanks
3. Sketch Up (figure 2)
4. Building New Frames and Painting Tanks
5. Implementing New Nursery System

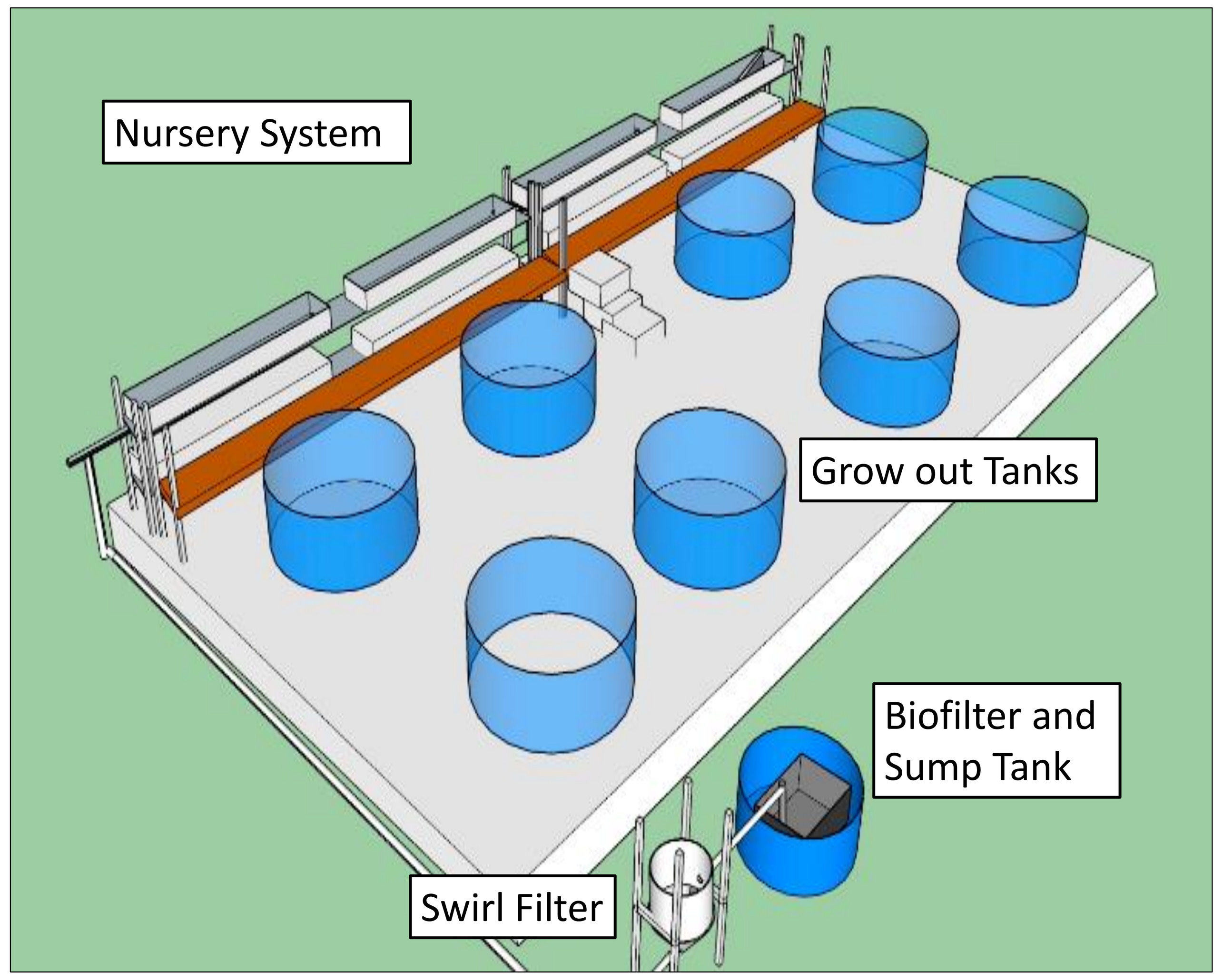

Figure 2. *Sketchup showing all elements of the design*

Results

During the month of October, this system experienced extreme fluctuations in temperature, as seen in Figure 2. These fluctuations occur due to daily weather patterns, seasonal changes, and time of day and are significant because although they are varied, they do not represent the estimated fluctuations for winter months which are projected to be greater. By implementing water heaters (see Figure 4) into an expanded system (see Figure 5), the temperature will remain at a constant state of 28° Celsius; the optimal temperature for Nile Tilapia (*Oreochromis niloctus*) to breed at. This will optimize system output and expand its full, year-round potential.

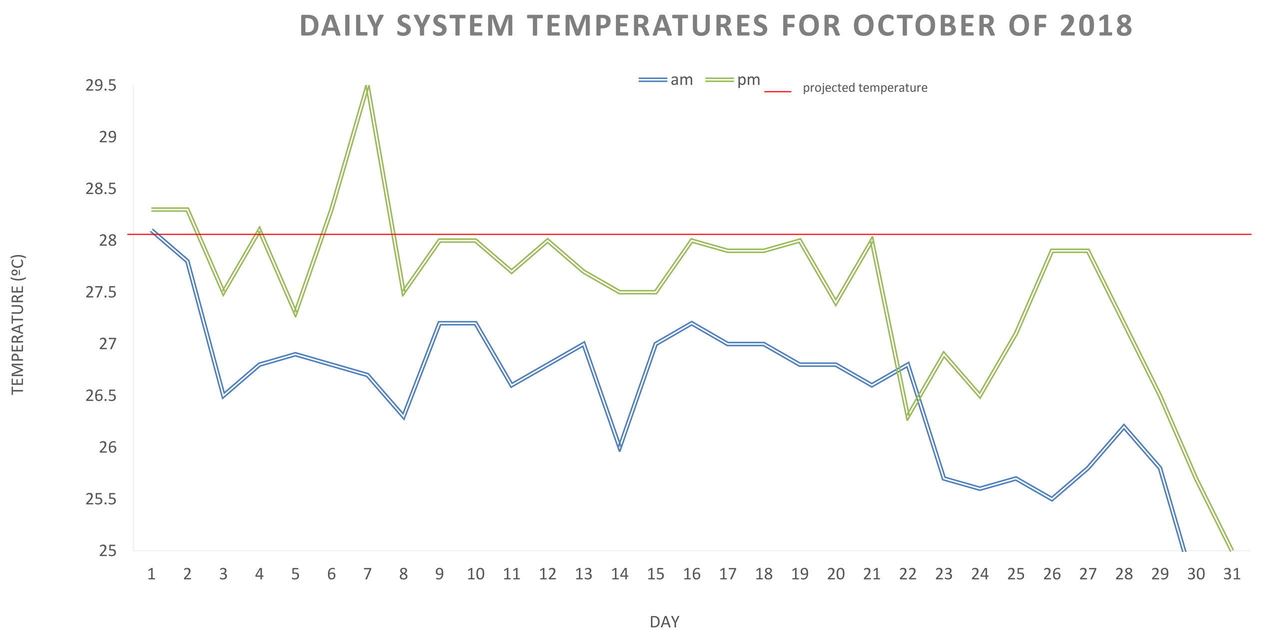

Figure 3. *Temperature fluctuations for the month of October experienced in the Island School system. (Actual AM/PM Temperatures : Blue and Green Lines, Predicted AM/PM Temperature with heater: Red Line)*

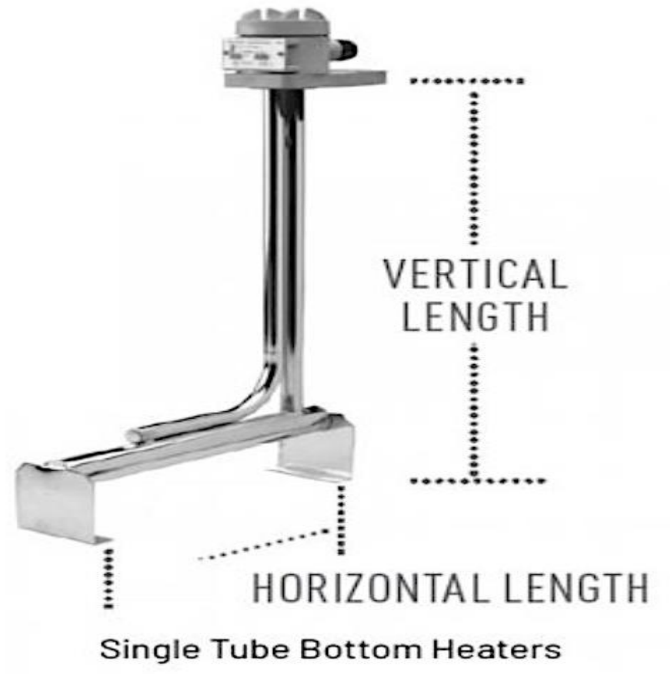

Figure 4. *Water heaters guarantee a constant temperature despite external fluctuations. This particular model, purchased from Pentair Aquatic Systems, was installed in the C.E.I.S. system.*

Discussion

Throughout the semester, an addition to the CEIS aquaponics system was engineered that allowed for on-site tilapia breeding all year round. Fluctuations due to external factors no longer impact the production rates of breeding tilapia because their tanks are climate-controlled by water heaters.

These findings are significant, as food security and the demand for food continues to spread, this system has proven that there is a viable, sustainable solution to feeding a growing population. The sustainability and accessibility of this system makes it ideal for families from inner-city communities to small island developing states (SIDS) like Eleuthera.

With the further expansion of this system, it may be possible to produce beyond the realm of leafy greens, though this may require more space, funding, and the introduction of a new species. Moving beyond the Island School campus, implementing systems of similar design across the Bahamas will be a momentous first step towards increasing food security levels, reassuring locals that despite limited resources and a less than ideal location for producing food, they will not go hungry.

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Figure 5. *New nursery and broodstock system at the Cape Eleuthera Island School (C.E.I.S.)*