Aquaponics in Prince George's County

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Executive Summary

A group of students and their mentor at the University of Maryland in College Park sought to contribute a solution to the issues of food insecurity and vacant or underused buildings in Prince George's County, Maryland. Students conducted research on the problems and determined that an indoor farming operation could solve both issues with one effort. Further research on aquaponics and hydroponics determined that aquaponics would be the best choice for the project.

The project has been modelled on an existing vacant building but is merely a case study in its current form. The building details were used to accurately discuss the technical aspects of an aquaponics system. The building location was chosen due to its proximity to public transportation, which was an important factor in this project. A prefabricated aquaponics system was chosen, and its specifications were researched for their production potential. Potential crop and fish species were discussed and evaluated for their production potential within this system.

The students also researched a potential budget for an aquaponics operation to include renovation, installation, labor, and other details related to running a business. Further investigation into efforts that would make the business self-sustaining are presented as well. This study also evaluates the project's potential social and environmental impacts on the community.

Lastly, the case study proposed a novel approach for future use of the project beyond the initial scope of small-scale crop production for local consumption.

Introduction

This project is a partnership between the University of Maryland (UMD) Environmental Science and Technology (ENST) Department, and the Prince George's County, Maryland Planning Department. The bridge between these two entities is the Partnership for Action Learning and Sustainability (PALS), which is an initiative to combine the strengths of UMD faculty and students to solve real sustainability problems in Maryland communities (University of Maryland, 2013). The collaboration of these three groups makes it possible to tackle complex community problems and propose lasting solutions.

The ENST students, with the leadership of faculty mentor Dr. Jose-Luis Izursa, have worked with these groups to construct an innovative and effective solution to the problems presented. This project seeks to alleviate food insecurity by utilizing vacant buildings for indoor urban agriculture. The goal is to be a guide in repurposing the vacant buildings, especially those owned by the county, while benefiting the communities they reside in. There are numerous benefits to introducing urban agriculture into community life. This proposal may also be useful to communities outside of Prince George's County.

1.1 Food Insecurity

Food insecurity is a crisis around the world, especially as the global population continues to grow. Stakeholders have a responsibility to address this crisis, particularly local and federal governments, urban planners, land grant universities (Creamer, 2016) and non-governmental organizations (NGOs). Due to a lack of understanding, food insecurity remains hidden in plain sight all over the world. It is not an issue that affects only rural populations or developing countries. It is not a lack of access to food in general, but a lack of access to nutritional food. Therefore, food insecurity can be present in any country and any community where people cannot reliably access healthy food. According to the 1996 World Food Summit, "food security... [is achieved] when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life."

"*There is a difference between eating to get full and eating to fill your body.*"
-John Settles II, Capital Sustainability

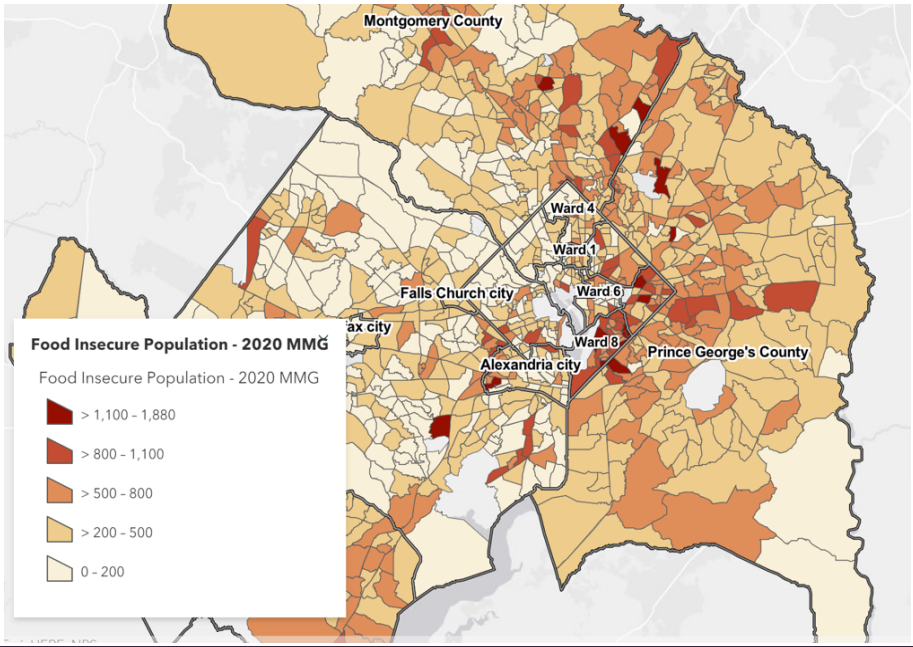
There are numerous causes of food insecurity in the United States, and often it is their combination that causes an individual to struggle. When low wages, a lack of affordable housing, and high medical bills induce financial stress, nutritional food is no longer a priority. To make matters worse, food prices are growing at a high rate of inflation, further linking income to food insecurity (Gustafson, 2013). Food deserts also strain the ability of communities to have consistent access to nutritional food. These deserts are low-income communities where residents have low access (needing to travel more than a mile) to grocery stores (Ploeg et al, 2009). Availability, access, and utilization are the three requirements to reach food security; that is, having enough food, being able to get it, and understanding the importance of a healthy diet (Abbade, 2017).

To confront the issue of food insecurity in Prince George's County, one must first understand the specific situations which have caused the problem. Data collected in 2018 by the County's health department indicates that 14.3 percent of children in the county are food insecure. Further, 17 percent of people who are food insecure in Maryland live within Prince George's County. There are approximately 20 food deserts in the County as of 2015 (Prince George's County, 2017), as shown in Figure 2. A majority of those who struggle with food insecurity are acutely aware of their problem. When surveyed, more than half of residents who receive food benefits responded that they would like to buy healthier foods if their benefits afforded them the resources to do so (The Maryland-National Capital Park and Planning Commission, 2015).

Data from the Capital Area Food Bank's *Hunger Report 2020* sheds light on the issues driving food insecurity in the region. It identifies Prince George's County's struggle with high unemployment rates, low education levels, and low median household income. The report notes that these numbers are some of the worst in the DC metropolitan area. As a result, many families struggle to put healthy food on the table, a condition exacerbated by the COVID-19 pandemic (Capital Area Food Bank, 2020). In fact, the pandemic has brought the County's food insecurity into the spotlight. Recently, the Prince

George's County Council passed CR-099-2020, to designate areas in the county as Healthy Food Priority Areas.

The updated index provides a strategic analysis of multiple community factors including transportation, census tract median income, and annual self-sufficiency income.



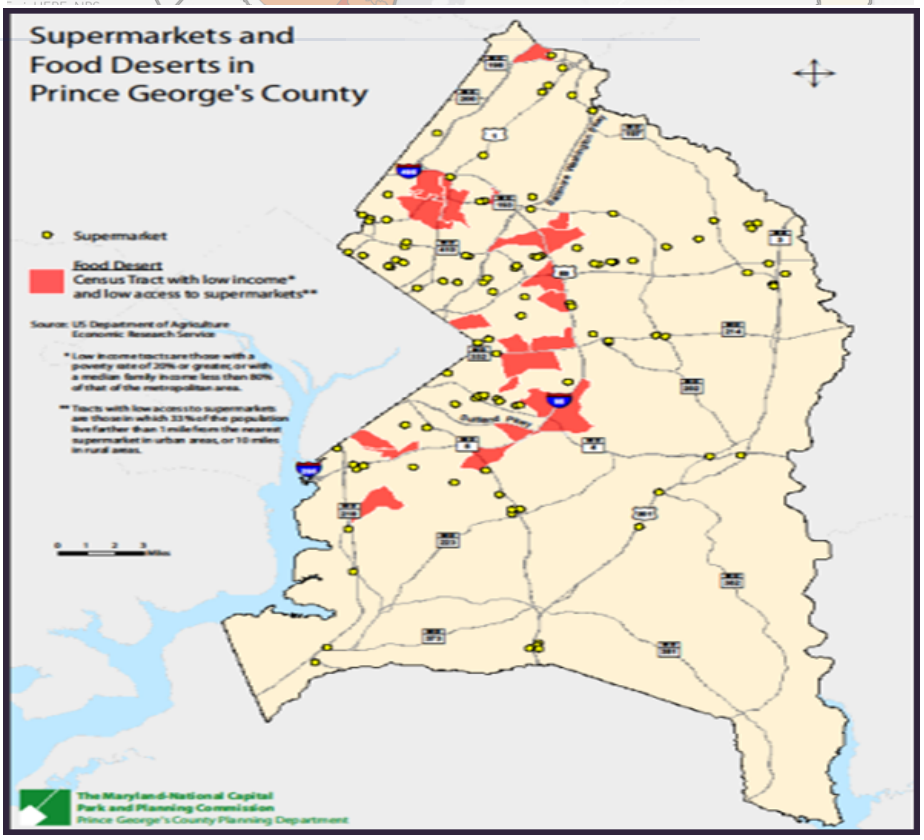


Figure . Prince George's County food deserts and supermarket locations (M-NCPPC)

1.2 Vacant Buildings

The second problem this proposal seeks to address is the number of vacant buildings throughout Prince George's County. The county lists 54 of its properties for sale (Figure 3), many with several vacant buildings on them (Prince George's, n.d.). This list doesn't include the dozens of buildings the county is holding for future use. Regardless, these buildings are not fulfilling their potential to contribute to the county, and the opportunity cost is a burden on taxpayers who could benefit from better utilization of these facilities.

The causes for building vacancies vary, but a few key trends can be identified. One is the suburban sprawl and the movement of people from urban to suburban areas. The shift in population can cause a vicious cycle whereby fewer people generate less business, stores lose customers, and are forced to close (Goldstein et al. 2001). More recently, the COVID-19 pandemic has closed many businesses, which have left the spaces they'd occupied (Farlie, 2020). These businesses have been under extreme financial pressure in this unprecedented time and many have not been able to cope with the economic stressors.

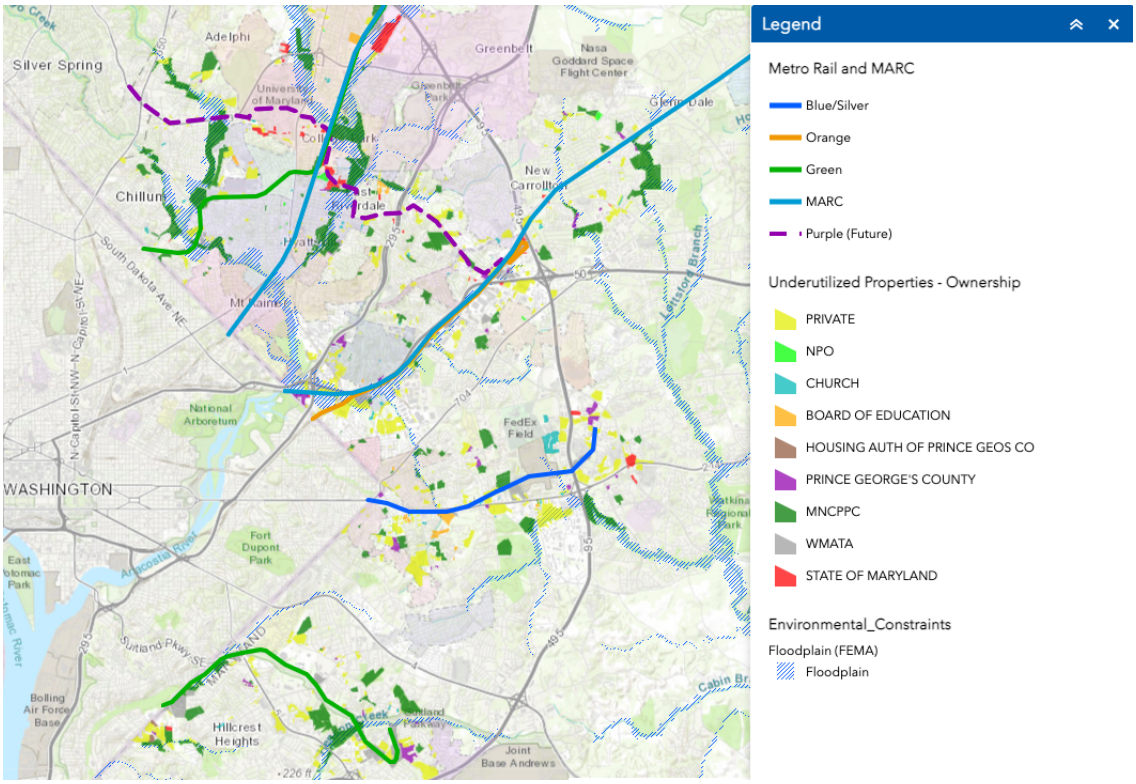


Figure 3. Underutilized properties in Prince George's County, MD (M-NCPPC)

Likewise, Prince George's County has no holding tax on vacant properties. A holding tax charges owners of vacant property a certain amount of money for each year they don't try to repurpose their building. As a result, many developers hold onto vacant properties without investing in them, hoping that property values will rise in 10 to 20 years, and they can sell their land for a profit (Personal Communication - Peter Shapiro). There are commercial buildings in the county that have sat empty for decades, to the detriment of the surrounding community, because the owners have no incentive to sell or revitalize the space, nor even keep the building or its surroundings clean.

Solution

Urban farming is defined as any type of agriculture within or in close proximity to a city (Wagstaff, 2013), and takes a step forward in serving the community. Food insecurity and vacant properties can be solved simultaneously by implementing urban farming into communities throughout the county. One wouldn't think that a farming operation could utilize a vacant building without an expensive demolition, but that is incorrect. Controlled Environment Agriculture (CEA) is designed to use an indoor environment that allowing crops to be grown continuously and production and harvesting to continue year-round. Rather than simply adding a community center or grocery store, urban agriculture presents an opportunity for individuals to have hands-on community building while having access to food.

There is a growing focus on urban agriculture to supply local produce and to repurpose unused buildings (McEldowney, 2017). Researchers in Manchester, England studied the potential of vertical aquaponics systems in underused buildings and concluded that the city could grow nearly $950 million worth of crops in a year's time (Jenkins et. al, 2015). Similarly, a study in Bologna, Italy found that green roofs could provide 77 percent of the city's vegetable demand if all roofs were converted (Safayet, 2017). However, urban agriculture is not just an experimental idea. In Rio De Janeiro, Brazil, urban food gardens have helped reduce crime and create economic and educational opportunities (Rekow, 2015). In New York City, commercial urban farming and community farming is allowed in nearly every zoning district (NYC Urban Agriculture, 2018), which has allowed a number of edible gardens to be cultivated and contribute to the community.

In Prince George's County, a number of small-scale urban farmers have laid the foundation for developing more extensive urban systems. Some examples include Envista Farms, ECO City Farms, and New Brooklyn Farms. Additionally, there is an emerging urban agriculture market. This is the direct result of recent regulatory changes that permit urban agriculture and farming in more locations. The implementation of projects using innovative methods of urban farming will allow Prince George's County to be a leader in sustainability. Prince George's County has a long and rich history centered around agriculture, and the use of urban agriculture to solve food insecurity can continue this history.

2.1 Aquaponics

This report examines and proposes a specific type of indoor farming practice, aquaponics. Aquaponics combines aquaculture, the growing of fish, and hydroponics, growing crops in water. In aquaponics, fish waste is turned into plant fertilizer via nitrifying bacteria. The plants absorb these nutrients and filter the water, which can be returned to the fish tanks. An aquaponics ecosystem mimics natural cycles and is an ancient practice that has been revitalized in recent decades (Jones, 2002).

The environmental benefits and production capabilities of aquaponics make it one of "ten technologies which could change our lives" (Van Woensel et al., 2015). It is likely that changing climate will make aquaponics a mainstream form of agriculture. In its modern adaptation, aquaponics balances hydroponics, aquaculture, and beneficial bacteria in one system. This is considered a circular system of resources, which uses fewer resources by design, resulting in the rapid production of quality food. Because the system operates indoors, pesticides are generally not required. Additionally, plant nutrition is provided by fish waste, eliminating the need for expensive and environmentally harmful fertilizers. The direct access to a local market that this case study project provides also means that packaging and shipping costs are reduced. Overall, aquaponics is sustainable, forward thinking, and presents educational opportunities for schools and communities. To make an informed decision, it is necessary to explore similar practices and conclude if aquaponics is the correct choice for the problem of food insecurity.

The aquaponics system, which combines hydroponics and aquaculture, takes advantage of the problems the practices often face as a byproduct of their design. Aquaculture generates fish waste, which is costly to remove and deadly for fish if ammonia and nitrite are left behind. It is possible to purchase biofilters or maintain a netted farm in an open waterway, but both of these solutions present their own costs. In aquaponics, that fish waste becomes a valuable resource. Solid waste, accompanied by ammonia, makes its way to the biofilter as water is pumped through the system. The filter's nitrifying bacteria break down ammonia into nitrate, while the water continues through the system. Nitrate is an essential plant nutrient. The abundance of this nutrient allows for a higher and faster crop yields. Hydroponics also utilizes the nutrient rich water to produce high levels of crop but without fish, these nutrients must be provided by the farmer at an added cost and which requires the farmer to flush the system to remove excess salt (Sink, 2016); ultimately a hydroponics system has a higher than desirable water demand and environmental impact.

While an aquaponics system offers many benefits, it comes with its own set of challenges. There is a limited selection of plants that can be grown compared to traditional agriculture, and some skill is required to understand the system's complexities (Underwood, 2017). This limitation may turn off many who are looking for a high variety of crops, and who don't want to wait for people to be trained in aquaponics.

The largest disadvantage is the initial cost and build, which can be daunting to the aspiring aquaponics farmer. When John Settles II, founder of Capital Sustainability, was asked what the highest cost would be, real estate came up first. "You don't get discounts for growing," he stated, adding that square footage costs are charged like any other retail building. As far as the system's cost, there are two options available. Pre-made systems need assembly or a system can be designed and built from scratch. Costs can quickly rack-up: materials, labor, and building renovation to accommodate the system. Continued cost include utilities and labor. Would-be purchasers can be assured that the costs of a properly functioning aquaponics system will reduce after the first year, once the one-time purchases are made.

Project Description

3.1 Building Description

The building in this case study is at 4701 Silver Hill Road in Suitland. It is part of a small strip mall built in the 1950s and was last used as a Rite Aid pharmacy. It is currently vacant and owned by the Prince George's County Revenue Authority, which has finalized plans for the space that are unrelated to aquaponics. Therefore, this site is solely being used as an example of a building that could be developed for aquaponics.

The building consists of a main level (11,600 sq ft) and a basement (7,800 sq ft). The main level has small rooms that can be converted into multipurpose rooms for meetings, offices, or community events. This main level will be for production, harvesting, and packaging vegetables (Image 7a). The basement will be used to raise fish (Image 7b). This space is ideal for growing fish because below-ground temperatures are consistent. Using the basement also opens up the main level for more vegetable production space.

It is important to note that any potential building must meet a few criteria. A commercial aquaponic system requires functioning water, sewage, and electrical utilities. Any potential building will need these services to minimize retrofitting costs. Additionally, any potential site must be accessible by public transportation to allow community members to conveniently shop and visit. The Suitland Metro station is a 10-minute walk from this property, and five bus lines run within two blocks of it. Additionally, the location experiences a high volume of foot traffic (Personal Communication - Brittney Drakeford). The area's major roads make the site ideal for distributing produce to various markets and customers.

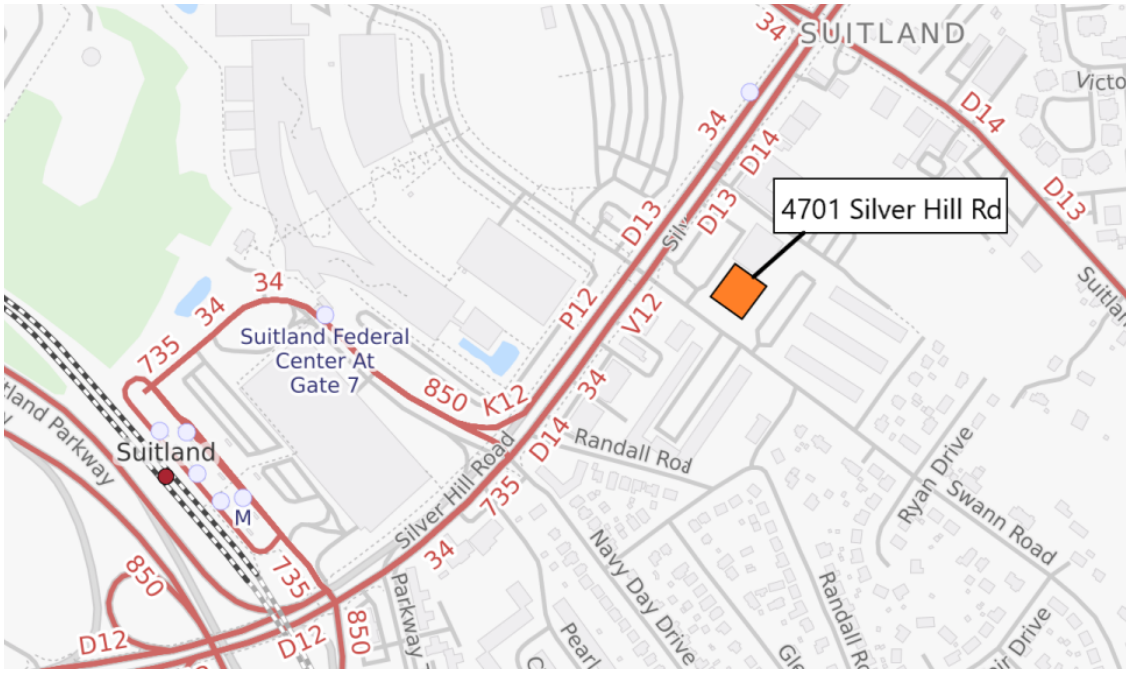


Figure 5. Hillcrest Heights transportation network around case study site (in orange). The red numbers indicate bus lines and the black and white dashed line is the Suitland Metro Station (Openstreetmaps.com)

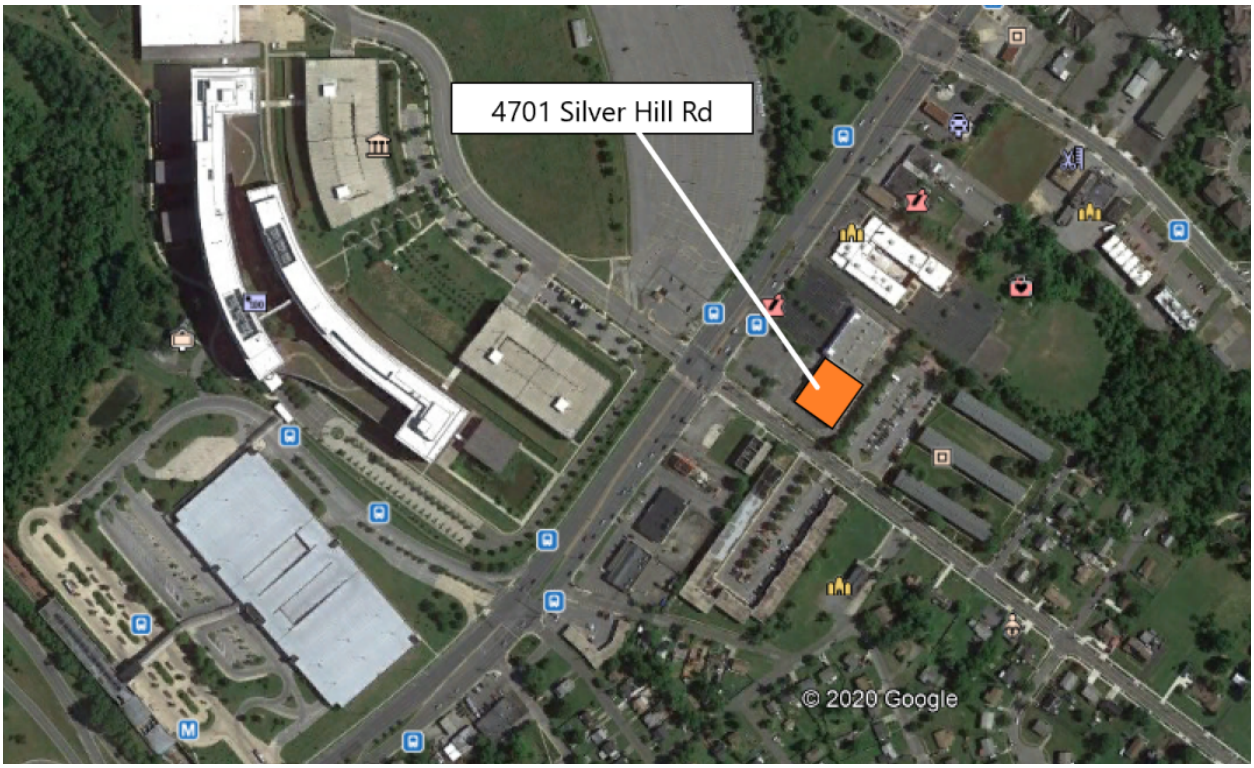


Figure 6. Satellite image of bus stops and Metro (in blue) near the case study site (Google Earth)

3.2 The Aquaponic System

A prefabricated commercial aquaponics system is the best choice for this project because it is easy to estimate a budget and simple to manage. Furthermore, premade systems are designed to optimize the system's amount of fish, plant, and nutrients to maximize output. There are many companies that offer a range of options, and specifications can be tailored to the individual building. This case study uses the Aquaponic Source prefabricated system. This system's specifications (dimensions, components, output, etc.) are available on the company website, which made it possible to begin project design. Also, this system incorporates both deep water and raised media beds, which allows for a larger variety of crops. Finally, the Aquaponic Source system is reasonably priced compared to similarly sized competitors which were also considered.

3.2.1 System Design

This design has been scaled from the Aquaponics Source premade system to fit the proposed site.

Fish tanks: Sixteen 500-gallon fish tanks. The tanks are 33-inches tall, allowing for easy accessibility.

Filtration system: The AST PG-12000 model filter allows for easy filtration and recycling of water within the system. It requires only one automatic backwashing filter per four fish tanks, which means only four are needed in total. These filters prevent the buildup of solids, and because they're automated, they reduce the maintenance requirements to control bio-media build up. Each filter is coupled with an aerobic mineralization tank, which anaerobically breaks down the filtered solids into usable nutrients, which can then be used by the system as needed. The deep water grow-beds also require filtration, as well as an active, carbon-filtered sump tank to add water as needed. The active carbon is important to prevent chlorine and other municipal water system chemicals from entering the system.

Plant production: This system includes eight deep-water culture troughs, whose dimensions are 8'x 80' with a total of 5,120 sq ft of production space. There are also four raised-media-beds, which provide an additional 288 sq ft of crop production. Crops seedlings begin in a nursery before they can be transplanted into the system's beds. This system's nursery will have two vertical tables which can hold 16 flats of seedlings and can double as a microgreens production area.

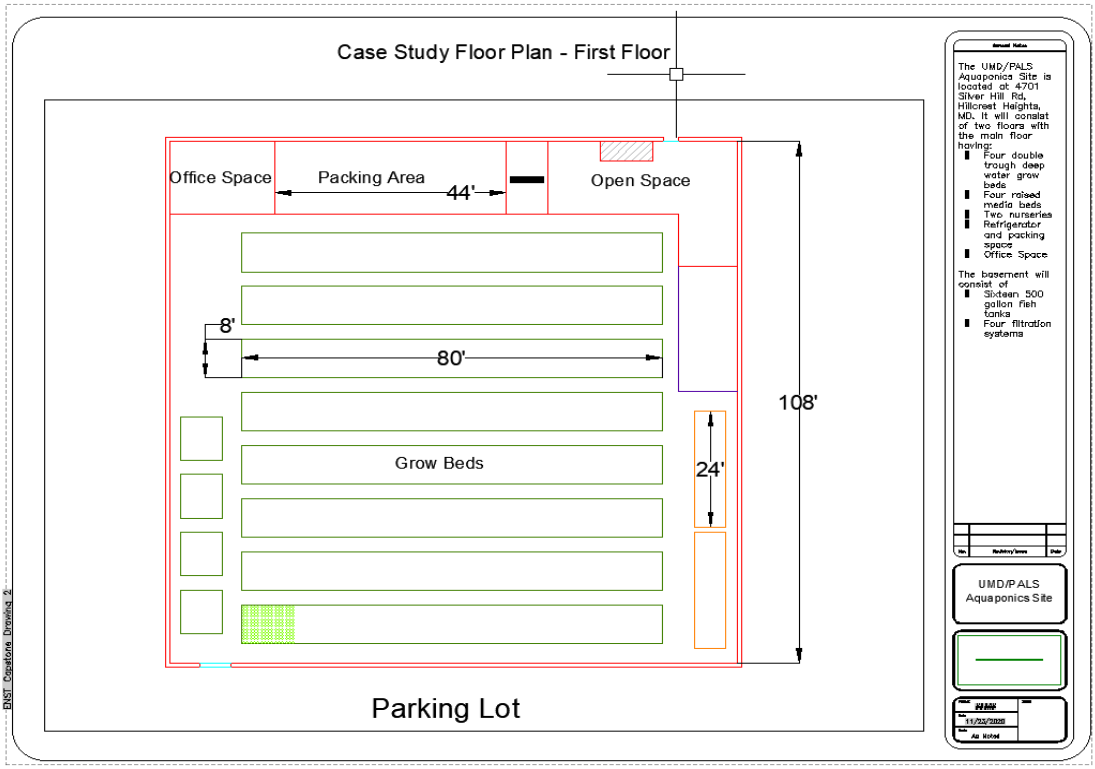


Figure 7. Main level floor plan of the case study site with the Aquaponic Source system

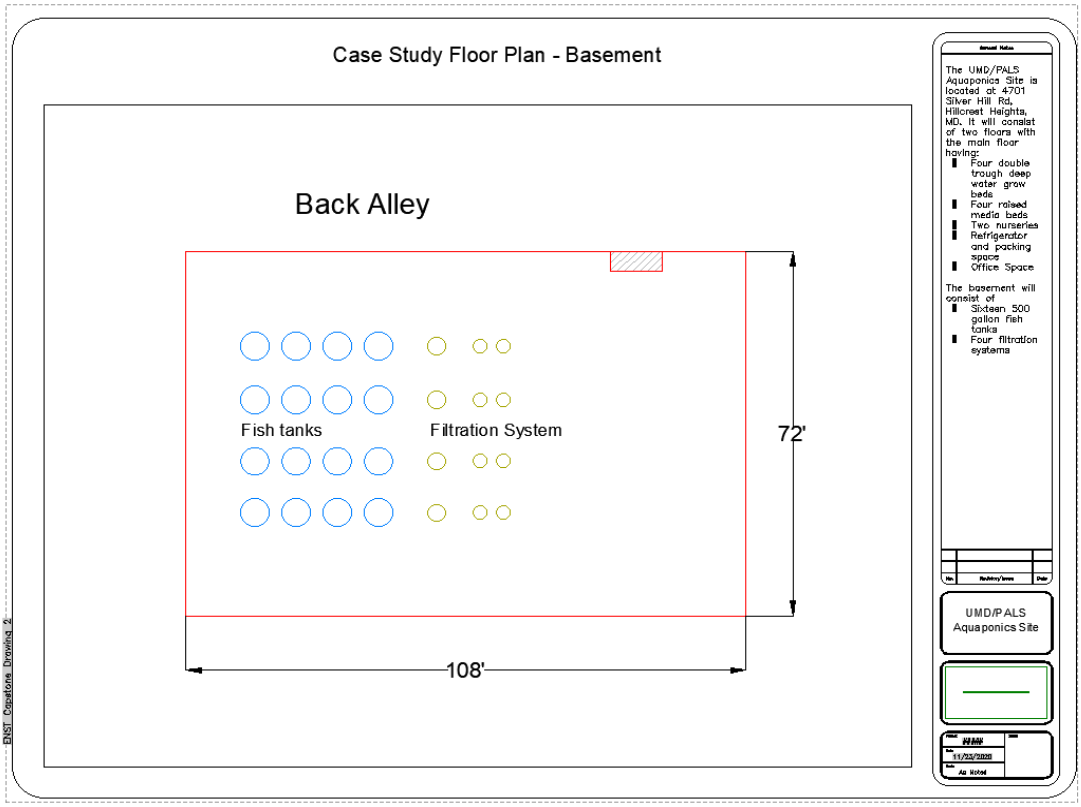


Figure 8. Basement level floor plan of the case study site with the Aquaponic Source system

3.3 Production

3.3.1 Crop Species

The species of crops evaluated in this project are some of the most common in aquaponics (Love et al., 2014) and there is a lot of knowledge on how to grow them successfully. For six of the eight crops listed, the pounds consumed greatly outweighs the pounds produced in Maryland. In fact, the Johns Hopkins Center for a Livable Future found that only 10.61 percent of all vegetables consumed in Maryland are produced in the state ("Maryland", 2015). Most importantly, these crops cover a full range of nutritional needs for an individual. It is important to note that this list is not exhaustive and in fact, a large variety of species can be grown in an aquaponics system.

Table 1. Potential Vegetable Crops

Crop	Growing media	Time to harvest	Plant Spacing	Harvest per sq foot annually	Estimated Sale price*
Lettuce	Water rafts	24-32 days	18cm	37 heads	$1.85/head
Swiss Chard	Water rafts	25-35 days	20 cm	5 lbs	$1.37/bunch
Basil	Water rafts	30-50 days	15 cm	5 lbs	$6.50/lb**
Broccoli	Media beds	60-100 days	50 cm	1.5 lbs	$1.45/lb
Cabbage	Media beds	45-70 days	70 cm	3 lbs	$0.55/lb
Cucumbers	Media beds	55-65 days	40 cm	10 lbs	$0.72/lb
Tomatoes	Media beds	60 days	50 cm	10 lbs	$1.58/lb
Bell Peppers	Media beds	60-95 days	50 cm	5 lbs	$1.44/lb

*- Sale price estimates from national average from National Retail Report - Specialty Crops 2020, USDA Agricultural Marketing Service
**- National average not available, based on market price in Baltimore, MD
Note: The harvest values in this table are estimates, some data was obtained from aquaponic companies and websites (http://www.aquasol.org/) due to the lack of professional research currently available.

3.3.2 Fish Species

The main focus of this research is to provide food for the community, and so the fish species must be fit for human consumption. For this reason, ornamental species such as koi have been excluded. Fortunately, a single system can have more than one fish species in it, allowing for variety and experimentation. Ultimately, the species of fish is not as important as the species of crop because most fish sell for the same amount, while different crops can dramatically alter overall profit (Pattillo, 2017). Finally, species are limited by what fish are produced in nearby hatcheries. The Maryland Department of Natural Resources (DNR) has hatcheries for game fish such as perch, bass, and trout

which can be acquired for free by the county ("Fisheries", n.d.). The species we recommend for this project include:

- Perch are adapted for cooler waters (Hart et al. 2006), which is preferable in a basement environment, where temperatures will be consistently cool year-round. They are carnivorous, which can become costly. They are slow growing compared to other species, taking three or four years to reach minimum harvest size (Hart et al. 2006). They are also difficult to breed in captivity (Sarkar et al., 2005), requiring specialized methods, or the periodic adding of adults to maintain the population (Hart et al. 2006). Despite these limitations, perch draws a high market value (Bosma et al., 2017).
- Catfish grow quickly and can be harvested in as little as three to six months. Catfish species are highly adaptable, but because they are bottom feeders, they will only occupy the bottom portion of the water column (Somerville et al., 2014). This ultimately means that some tank space will be wasted, and overcrowding can be an issue. However, catfish are a commonly consumed fish and should have high market demand.
- Tilapia are the most commonly used species in aquaponic systems (Love et. al., 2014), chosen for their fast growth rate, high marketability, and hardiness (Perschbacher and Stickney, 2017). One drawback is that they require high water temperatures and deviations can stunt growth or kill this species (Rakocy et. al. 2003). For this case study, tilapia is the least viable option, due to the temperature constraints of a basement environment. These fish are otherwise excellent potential candidates.

Table 2. Potential Fish Species

Species	Time to Harvest	Average Weight per Fish	Ideal Temperature Range	Average Market Price	Fish density
Tilapia	7 months	2 lbs	75-86 F	$2.30/lbs	0.5 lbs/gal
Perch	3-4 years	2.2 lbs	67-77 F	$5.50/lbs	1 lbs/gal
Catfish	3-6 months	2-3 lbs	70-80 F	$1.14/lbs	0.125 lbs/gal

3.4 Production Potential

Production potential for fish is calculated using fish density, total number of gallons in the system, and time to harvest. The production potential for crops is calculated using estimates from The Aquaponics Source and the square footage of the system.

- 2,285 lbs of perch per year in a four-tank stocking rotation with a maximum adult stocking density of 1 lbs. per gallon. (8,000 gallons x 1 lb/gal = 8,000 lbs, harvested every 3.5 years = 8,000/3.5 = 2,285.71 lbs of perch per year OR
- 2,000 lbs of catfish per year (8,000 gallons x 0.125 lbs/gal = 1,000 lbs, harvested twice a year = 2,000 lbs of catfish per year)

- 11,200 heads of lettuce per week / 160,000 heads annually for all with deep water beds dedicated to lettuce
- 360 lbs of tomatoes seasonally if all media beds dedicated to tomatoes
- Nine microgreen flats per week if half of the nursery space is dedicated to microgreens

Table 3. Potential Systems

Name	Cost of System	System Dimensions	Produce Production per yr	Fish Production per yr	Potential Revenue
FarmTek	$3,539 - 82,459	12'x20' - 60'x96'	168-4704 lettuce heads	90-10,000lbs tilapia	$ 31,702.40
Aquaponic Source	$49,500	30x96'	40,000 heads, 700lbs tomatoes	1,000lbs	$ 76,804.00
Nelson and Pade	59,995 - 84,995	30x110' - 42x140'	appx 38,000 - 95,000 plants	1,900 - 6,000 lbs tilapia	$ 189,550.00
Enterprise Aquatics	8,975 - 19,750	800 sq ft - 16x48'	up to 11,000 heads	up to 900lbs	$ 22,420.00
Portable Farms	no data available	10x20 - 100x100	1,100 - 80,000 heads	400 - 23,000 lbs	$ 200,900.00

3.5 Labor

Labor is an important factor in the design of any business, and, after the initial build, production is the most labor-intensive aspect of aquaponics (Tokunaga et al., 2015). Tasks for vegetable production include seeding, transplanting, harvesting, processing and transporting the products. Fish rearing is a simpler process; they require once-daily feeding and are only harvested periodically. It can be expected that water levels must be monitored daily, as well as water quality in tanks and beds. This system doesn't require 24-hour surveillance (EPA, 2016). According to Aquaponics Source, 40 hours per week is required to get the most out of a system. This case study uses four systems, so it is reasonable to expect that labor needs may increase beyond this number. We estimate that this project would require two full time staff (40 hours/week), two part time employees (20 hours/week), and a knowledgeable manager.

3.6 Food Distribution and Transportation

To succeed in combating food insecurity, it is necessary to understand what prevents individuals from having access to healthy food. Interviews with county leaders indicated that transportation plays a large role in food insecurity. Often, community members have the money to buy healthy food, but don't have access to a bus route or car to reach the stores that sell it (T. Kowalski,

personal communication, October 10, 2020). For this reason, this project aims to take advantage of public transportation near the building and establish a co-op outside the facility. As seen in Appendix A, parking will be provided for workers and customers who have access to a car.

To save time for potential customers, the farmers' market will offer food bundles so that people can get in and out quickly. A food bundle will have a set mix of produce and fish sized for individuals and families. This option will ensure that customers will have access to a variety of produce, regardless of when they can pick it up. Customers can also shop for individual items. Distribution can also take place at the nearby Suitland Community Center. The business should also be able to accept Supplemental Nutrition Assistance Program (SNAP) members, so that those who need food will have access.

In addition to providing food for those in need, the project also aims to be as self-sustainable as possible. For this reason, the business must have transportation to more established farmers markets to sell products. High value crops such as basil and swiss chard can produce a substantial profit, and can be sold as fresh, organic produce to restaurants and farm market customers. Additionally, the business should establish a community supported agriculture (CSA) program, to get and retain regular customers. These practices will help generate revenue as well as exposure for the business, which allows the mission of feeding those in need to continue.

Costs/Budget

Table 4. Budget

Building	Component	One-time Expense	Yearly Expense
Repair and fix several sections of the building			
Walls, pipping, bathrooms, HVAC system		$100,000	
System	**Component**	**One-time Expense**	**Yearly Expense**
Pre-made Colorado Aquaponics system			
Four full systems including grow beds, fish tanks, and nursery.	System	$216,000	
Grow lights			
Grow lights are required for indoor vegetable production.	Lights	$24,675	
Operations	**Component**	**One-time Expense**	**Yearly Expense**
Utilities			
Necessary to power grow lights, pumps, and water to run through the system. The initial water fill will be the costliest, after which only top-offs will be needed.	Water		$282.20
	Electricity		$1,500.00
Labor			

The system will require a small team of employees to run the system and produce food. These are based on average manager salary and $11.60 Maryland minimum wage. We estimate one manager, two full time employees, and two part time employees will be needed.	Manager		$48,000.00
	Full-time (2)		$44,000.00
	Part-time (2)		$22,000.00
Seeds			
Seeds will need to be purchased in bulk once a year based on the crop plan.	Lettuce		$870.00
	Cabbage		$328.00
	Tomatoes		$195.00
Fingerlings			
Fish will be purchased as fingerlings and raised in the tanks. The Maryland DNR provides fingerlings free of charge, so long as there is proper permitting.	Perch		No Charge
	Rainbow Trout		
Rafts			
Floating rafts are used in the deep-water beds to produce leafy greens. 160 rafts are needed per deep water bed totaling 1,280. Rafts can be purchased from the company, and last beyond one use.	Water Rafts	$26,880.00	
Harvesting			
Materials to assist in harvesting processes include pruners to cut vegetables, as well as materials to wash and pack produce for transport. A walk-in refrigerator will also be needed to store produce.	Equipment	$500.00	
	Cleaning	$600.00	
	Packaging		$5,900.00
	Storage	$7,000.00	
Transportation			
A vehicle will be needed to transport produce for sale. There will also need to be a refrigerated trailer to keep produce fresh on the way to the market.	Truck	$35,000.00	
	Trailer	$4,000.00	
Education ($10-15k)			
A small budget for education resources, such as informative posters and signage as well as a stipend for interns to learn and help with the operation.	Materials	$2,500.00	
	Interns		$10,000.00
Total Costs		**$417,155**	**$133,075.20**
Total			**$549,055.20**
Revenue Estimate			
Revenue for one system assuming 40,000 heads of lettuce, 700 lbs tomatoes, and 1,000 lbs of tilapia per year			$76,804.00
Total revenue for our system			$307,216.00
Net profit assuming all produce is sold at market	Net Total		**$174,140.80**

Project's Impacts

5.1 Social Impacts

There are numerous social benefits of an urban agriculture operation to solve the issues of food insecurity. The most obvious benefit is the ability to provide options to a community which lacks access to healthy food. An added bonus is this service can be provided year-round because an aquaponics facility is not dependent on the season. The social impact extends beyond full bellies. Adults who struggle with food insecurity are 32 percent more likely to be obese (Pan et al, 2012) and children are five times higher chance of obesity (Kral et al, 2017). The physical and mental benefits of a healthy weight are no secret, and all members of the Prince George's County community deserve access to these benefits. No child should grow up under circumstances which affect their health and future so drastically, simply because of where they live.

Our project seeks to address food insecurity, but also the issue of vacant or underused buildings. There is a positive social effect to reducing the number of these buildings. Studies indicate that vacant properties attract a higher level of criminal activity to surrounding communities (Cui & Walsh, 2014) and negatively affect area property values ("Vacant", n.d.). This is an obvious frustration for community members, as the buildings don't belong to them and can't be improved by them. The implementation of a community run urban farm could address many of these problems.

Community building can also result from urban farming. When families are able to see where their food comes from and perhaps assist in its production, community pride takes a stronger hold among individuals. Urban farming can also provide another service to the community, education. With an aquaponics operation within the county, schools can plan field trips and service-learning opportunities for their students. Within five miles of the case study building are 15 schools ranging from preschool to high school (Google, n.d.), making the project accessible to potentially hundreds of interested students. An aquaponics facility presents an opportunity for research and internship opportunities for students at University of Maryland, Prince George's Community College, and independent learners who may want hands-on experience or to gain and maintain certifications.

The proposed project is still a business and will create a need for labor. These jobs will include the renovation and installation of the system, and lasting jobs of those who will grow and distribute the food. It will create internship opportunities and a more specialized job field. An opportunity for specialized work has been shown to bring greater satisfaction to individuals than simply making money (Goetz, 2012). While the initial costs of the system seem high, the long-term benefits of aquaponics exceed these costs. The ability to have locally, sustainably grown food year-round, to educate children and adults, to improve and build communities, and create meaningful jobs far outweigh the initial investment.

5.2 Environmental Impact

An aquaponics operation which utilizes vacant buildings presents an opportunity for Prince George's County to explore new avenues in sustainability. An important factor of sustainability in this project is the transportation differential. Studies show that some produce travels 3,000 miles or more to market (Raudenbush, 2017). The vehicle emissions may seem insignificant, but the US produces over 50 billion dollars' worth of fruits and vegetables every year (USDA, 2019). This produce is often grown and processed in different locations, then driven to markets. The end result is produce with a high carbon footprint, with a journey that is a mystery to the consumer. Food miles are not the largest environmental impact of food farming. Water consumption is an increasing problem, especially with water shortages occurring worldwide ("Water", 2020). Therefore, an additional positive environmental impact of an aquaponics system is its low water consumption. Aquaponics uses water more efficiently than other farming practices, even hydroponics, yet produces the same results (Suhl, 2016).

Another advantage is that aquaponics systems don't rely on chemical fertilizers or pesticides. The application of pesticides contributes to water and soil pollution, harms pollinator populations, and can lower soil fertility (Aktar, 2009). Thus, a farming practice that doesn't require pesticides or fertilizers is ideal. Fertilizers aren't added to the system because the fish waste provides nutrients for the produce crop. Finally, fisheries alone produce an incredible amount of waste (Barinaga, 1990), which makes small-scale aquaponics farming a more sustainable way to obtain fish without contributing to unsustainable practices.

Finally, environmental issues can arise from vacant buildings, even if the building has an owner. These issues include improper upkeep due to the lack of activity on the property. For example, illegal dumping taking place on the property, sometimes resulting in pollution of the surrounding area (Duncan, 2013).

Conclusion

The issues of food insecurity and vacant buildings will continue to plague our communities until we take direct action. The effect of food insecurity on health is clear, and the effects of vacant properties can be seen in communities.

Our project is designed to be sustainable and efficient. Rather than a food pantry that relies on donations or buying food, a local business could directly create healthy food for the community. An aquaponics system perfectly fits the requirements for such a business. By testing a building that meets the required specifications, this case study was able to demonstrate the production potential of an aquaponics operation. This finding allows for other buildings to be considered, and a possible expansion of operations when the project is a proven success. The provided budget can help prepare would-be farmers understand the expected costs, and the social and environmental impacts were evaluated for their potential community effects.

We believe an aquaponics farm would be productive and sustainable enough to meet the needs of Prince George's County communities that face food insecurity, while providing jobs and tackling the

issue of vacant properties. This project would also provide educational, research, and environmentally sustainable opportunities.

If there is one certainty in this project above all others, it is that citizens who suffer from food insecurity cannot wait any longer for help to arrive. It is the responsibility of those in power to make decisions that will improve the lives of as many people as possible, and aquaponics can help do that.

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Appendix

Appendix A. Stakeholder Interviews

John Settles II
Interviewers: Catherine Moses, Dr. Jose-Luis Izursa
10/20/2020

1. **In your own words, what is the mission of Capital Sustainability?**
   a. Fuse triple bottom line (sustainability) economics, environment, people
   b. Lots of experience with real estate, community entrepreneurs
      i. Community—real estate—sustainability
      ii. Focus on climate change but only in their own business, not all-around solutions and equity (food, workforce development)

2. **What work has Capital Sustainability previously done in Prince George's County (if any)?**
   a. More on policy side. Work with MWCOG; Staff member ran food program in Montgomery County. Look at farm to table, including factory use. Areas of Montgomery County zoned as farms but not being used as farms
      i. Person lives in one state and produces product in another
      ii. Greendoor healthy food and mental health
   b. Most common problem?
      i. Not just one. Economics (finance for projects and buyers)
      ii. Companies will always take the cheaper product
      iii. Lack of awareness and education; there is a difference between eating to get full and eating to fill your body
      iv. Poverty, lack of healthy food and grocery stores
      v. Transportation is an issue

3. **Any work with aquaponics?**
   a. "Enough to be dangerous"
   b. Worked with, taken classes, certification with UDC: have a farm in Beltsville
   c. HUGE ENERGY DEMAND IS THE BIG PROBLEM (carbon footprint)

d. Aquaponics in containers: mobile to move to areas to problems
e. What is the biggest problem? Energy is problem but real estate cost is more "You don't get a discount for growing," still charge sq ft like normal retail

4. **Regulations?**
   a. Govt could help with planning and permitting; anything out of the box takes longer to get done; need timelines and certainty
5. **In your work in sustainability, do you see a trend toward non-traditional farming practices such as aquaponics?**
   a. See it as one of the major solutions
   b. Current model is fragile: COVID brought it to light
   c. "I think COVID laid bare the fragility of our current model"
   d. Should have hoop houses on park property to get things done as a co-op; owned by community

Ted Kowaluk
Interviewers: Kurt Willson, Catherine Moses
10/13/20

1. **What is your role in Prince George's County government?**
   a. Research department, background in economic development, tracking housing and real estate market, did solar guidelines for county
   b. Zoning: often there are no guidelines in place for new types of operations, are we allowed to put it into a commercial/retail center. Industrial should/is easier in terms of zoning. Brittney knows a lot about zoning!
      i. Issues from a retail space? Not sure. Lots of water use, can the structure handle it? Issues with where the waste goes, amount of waste, (more concern, industrial spaces more equipped for this)? Traffic-wise, not really. Energy? More about liability for owners when it comes to retail space.
      ii. What would be appropriate for a retail space? From a financial perspective, industrial is lowest priced space but also hard to get (lots of competition) 10.71 sq ft in College Park as an example. Vacancy is very low, (4-5 when healthy 7). Different levels of space (A, B, C) C is lower quality but location can make it more expensive. Average is $7-8 sq ft for retail. But $22-26 in College Park!
      iii. Lake Arbor foundation - zone residential and so not allowed.
      iv. Ted can use Costar to look at what is vacant in an area, what the space is renting for, etc., but can't speak to specific buildings or violate copyright (generalize sq footage). He is ok with helping us in the future.

2. **What role do you believe the government should play in combating food insecurity?**
   a. Food deserts: not really about that, mostly income and transportation the problem

3. **What is the state of farming in Prince George's County?**
    a. Agriculture census: continued loss of farm and production in county. Statewide, county is at the bottom. People are trying, but need the supporting industries too (seed, fertilizer, equipment service, etc.).
    b. Lots of farms going to Virginia because there are more supportive industries. Possible that there is a shift toward nontraditional farming, but large-scale production is going way down. Agritourism is more popular.
    c. What does the county want with farmers?
        i. When solar started, there were lots of applications for solar (back when counties were trying to prohibit it from ag land, Prince Goerge's County took a different approach) worked with soil conservation, still wanted farmers to have control. Proposed dual land use to do this, but vague (pollinator garden counted) and not hitting the mark.
        ii. Does the county want to invest in urban agriculture? It might have better support, but so far actions are not showing this. However, county is motivated by employment! Economic incentive fund is a big thing, building and maintaining it included.

4. **How involved is M-NCPPC with other branches of Prince George's County government?**
    a. Public schoolsland may have zoning issues, just like golf courses. Sometimes they are in industrial underlying zones, so this may be a way around.

5. **How much data do you have on food insecurity?**
    a. Goule G - It was mainly income and transportation that created the food desert and food insecurity.
    b. From personal opinion: location is not the issue, transport and distribution is. That is something that farmer/producer should worry about, and more important than location. Have a great distribution plan.
        i. CSA near here takes food to DC to distribute.
        ii. The county would benefit from putting urban agriculture in an area that needs to create jobs, so that may help to get them to go for it.

Peter Shapiro
Interviewers: Erin Hyman, Kurt Willson, Andrew Prinn
10/27/20

1. **How familiar are you with the issue of food insecurity in Prince George's County?**
    a. Have become more aware with pandemic
    b. Been involved with conversations around food deserts
    c. LILAs: Low Income Low Access

d. Trying to build food components into new building projects

2. **What are some of the main causes of vacant commercial buildings?**
   a. Have to be more specific as to what type of vacant buildings
   b. Currently a lot of vacant retail space that predates pandemic
   c. County economy lags behind other MD counties
   d. Can't get rental rates that you can get in other jurisdictions
   e. But that means cheaper real estate
   f. County has a lot of developable space
   g. Commercial tax base is not where they want it to be
   h. How often do buildings become available?
      i. Depends on where and what
      ii. Some developers are holding onto properties and waiting for their value to go up
      iii. Not a lot of empty industrial in the county because there is a good market for that

3. **Do you think that using these buildings as indoor farming operations is a feasible option?**
   a. Could benefit the county
   b. Address food insecurity, provide jobs, viable industry in the county
   c. Ties into agriculture background

4. **Is there money in the current budget to support new projects?**
   a. Short answer is yes but there is a lot of competition for funds right now
   b. If county executive thought it was a good idea the project would be funded

5. **Would adding an educational aspect to the project make this business a more intriguing prospect?**
   a. Definitely makes it more attractive
   b. Means there are different sources of funding if there is an educational edge
   c. A possible vocational training aspect
   d. SSL hours
   e. Field trips

6. **What ideas do you have to make this project more appealing or likely to earn money and support from the county?**
   a. Some ideas are "sexy" e.g., if it became a news story
   b. If it creates jobs and helps educate people in unique ways
   c. Ties into more broad issues
   d. County executive will be oriented around food insecurity and equity
   e. Show how the county can step out in front of other counties

7. **How would a project like this impact property values, both for the property and the neighborhood around it?**
    a. Can you mitigate noise and smell?
    b. Is it compatible with residential areas?
    c. Very low intensity use
    d. Added amenities (coffee shop, co-op) would make it more attractive

Kevin Doyle
Interviewers: Erin Hyman, Kurt Willson
10/12/20

1. **When did you start using aquaponics and how did you first learn about the practice? Is this your first experience with farming?**
    a. Worked in commercial real estate development
    b. No agriculture background
    c. 2014-2015: originally set up as financial help for getting a university in Africa with a hydroponic farm attached
    d. 2016-2017: set up a hydroponic system at a Prince George's County church
    e. Tried pilot programs in poultry houses

2. **Did you start from scratch or by using a commercial system?**
    a. Built entire system from scratch
    b. "Flintstones of technology"
    c. 9.5 ft wide x 40 ft
    d. 37 dozen basil units per week (have 7 and are adding 7)
    e. 48,000 sq feet total
    f. Tables cost $40/sq ft with lighting, aeration, etc. (capital)
    g. $20,000 to get electrical set up correctly
    h. Each table runs at 7 amps

3. **Why did you choose to use aquaponics and what were your original goals when you first began?**
    a. Wanted to create/produce something

4. **What were the biggest obstacles in starting the farm? (cost? location? access to materials?)**
    a. Needed to keep capital costs down

b. People to take care of the system - currently 2 people but expanding as the facility grows
c. One person can handle 5 tables a day so they will need around 20 people at full capacity

5. **What do you produce and how do you distribute your produce?**
   a. Largest customer: supermarkets every other day, sell to 50 stores
   b. Leafy greens
   c. Basil
   d. 48,000 sq ft of space, which can hold 80 tables
   e. Can't miss a delivery to a store because they have expectations

6. **Who works on your farm (volunteers, paid employees, family, etc.), and how much labor is involved in maintaining your business?**
   a. Two staff, himself and a UMD grad
   b. Need about one staff per 5 tables

7. **What item/factor of the business takes up most of the budget?**
   a. Configuring the electrical set up

8. **Are there any county or state laws, regulations, or standards that negatively impact your business?**
   a. Food safety certifications
      i. Water quality
      ii. Clean hands
      iii. Plant care
   b. Classified as a food manufacturer

9. **What has been an unexpected benefit from working on these aquaponic systems?**
   a. Can source the market and switch production relatively quickly
   b. Has no attachment to growing a specific selection of crops

10. **What are some of the challenges?**
    a. Access to capital
    b. Not a lot of support
    c. The work is the same every day

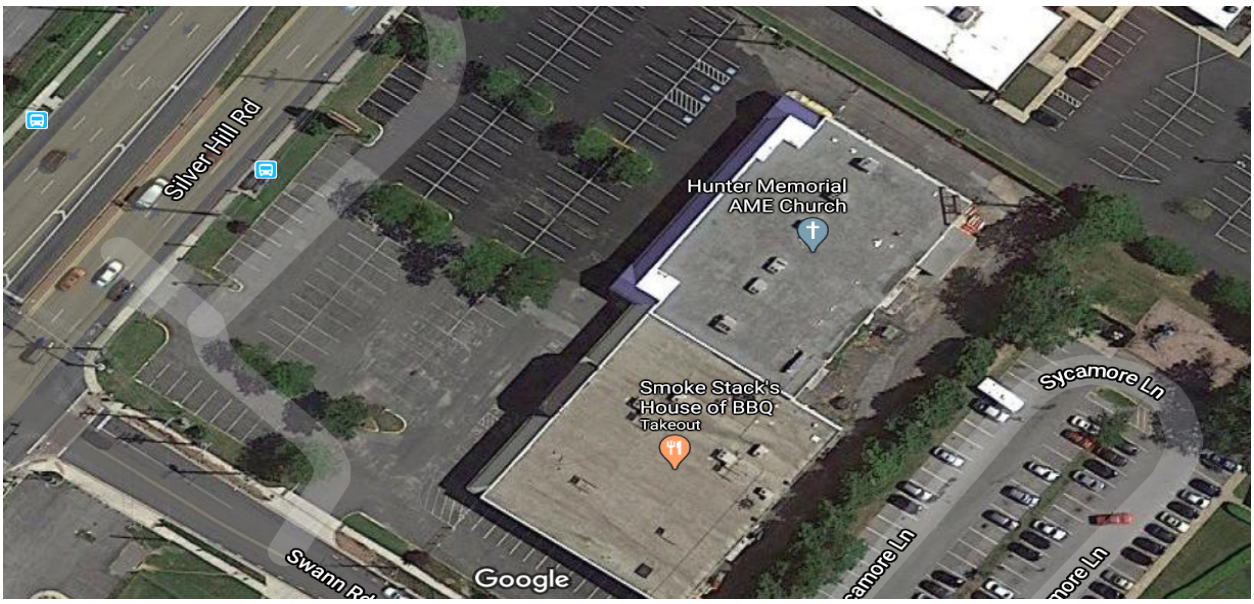
11. **What is your protocol for dealing with these challenges?**
    a. Start at the opposite side of the equal sign
    b. Find what will do the best in the current market

12. **Do you have any plans for the business's future: expanding to new locations, hiring new employees, or implementing vertical integration?**
    a. Can grow leafy greens and basil together despite the different climates they require
    b. Filling out the space they have now, and adding employees

13. **Do you expect a decline in traditional farming practices as alternative technologies improve?**
    a. Smaller hydroponic farms will probably grow because they are more traceable and they travel a smaller distances
    b. More buildings available now because COVID has forced a lot of people out of business

14. **What advice would you give to an aquaponics farmer who wants to start a small-scale commercial farm?**
    a. Have to be strategic in how you source the things you use

Appendix B. Aerial View of 4701 Silver Hill Road (case study building)



Appendix C. Farm Cost per The Aquaponics Source

Greenhouse Model Dimensions	23x40	30x52	30x96
Total sq ft	920	1560	2880
Flourish Farm Aquaponic Systems			
Base System Package	$24,500	$32,500	$49,500
Base System Cost per sq ft	$27	$21	$17
Optional Upgrades	$6,595	$6,770	$7,570
Consulting, Installation and Support Services	$6,110	$7,060	$9,610
Shipping Estimate	$2,500	$3,000	$3,500
Total System with Options	$39,705	$49,330	$70,180
Total System Cost per sq ft	$43	$32	$24
Ceres Passive Solar Greenhouses			
Base System Package	$41,250	$62,000	$98,690
Base System Cost per sq ft	$45	$40	$34
Optional Upgrades Estimate	TBD	TBD	TBD
Installation	TBD	TBD	TBD
Est. Shipping @ 15% of Base System Cost	$6,188	$9,300	$14,804
Total System with Options	$47,438	$71,300	$113,494
Total System Cost per sq ft	$52	$46	$39
Total Aquaponic and Greenhouse Costs			
Total with Options, Installation and Shipping*	$87,143	$120,630	$183,674
Total cost per sq ft	$95	$77	$64
*Taxes not included			
Production and Energy Comparison	**23x40**	**30x52**	**30x96**
Total Growasis Planting Spaces	1,064	2,234	4,480
Weekly Heads of Leafy Greens from DWC	210	450	880
Annual Fish Production in lbs	327	614	795
Energy in kwH per mth (Aquaponics Only)	420	607	920
Estimated Farm Management Time	20	30	40

Appendix D. Grow Light Specifications per The Green Sunshine Company

Specifications

CHECK BACK SOON FOR PPFD CHARTS & FURTHER VERSION 3 DETAILS

Input Power / Voltage	330W / 100-277V
Energy Use Per Day @ $0.15/kWh	Flower (12 hours on): $0.59 per day Veg (18 hours on): $0.89 per day
Amperage	2.75A @ 120V / 1.375 @ 240V
Dimming	0-10V – Dimmer and Daisy Chain Kit Included
Heat BTU Generated	1,125.3 BTU
Spectrum:	GS3 Wideband Spectrum – Continuous 400nm – 780nm response
Human Eye Appearance	2300K & 91 CRI
Diode Count	864 Diodes
Photon Efficiency [300nm-780nm]	2.47 Umol/J*
Fixture Dimensions / Weight	36L x 12W x 2.4H in / 22lbs
Power Cord Length & Type	10' Cord – C14 Socket – Compatible with C13 Plugs and Adapters (Standard Power Cords)
Flowering Hang Distance / Coverage	18" / 2'x4' -2.5'x5' area
Vegetative Hang Distance / Coverage	36" / 3'x6' – 3.5×7' area
Warranty	3 Years Full
Expected Fixture Lifetime	70,000+ Hours [16 yrs flower / 10.6 yrs veg]
Laboratory Tested Certification	ETL, CSA, CE, RoHS, RCM Listed for Worldwide Use

* Efficacy is measured at board level and measured from 300-780nm . Efficiency increases as the fixture is dimmed. Wideband diodes create near red and infrared light above 680nm, critical nutrients to plant growth.

Appendix E. Photos of 4701 Silver Hill Rd, Hillcrest Heights, MD