



# URBAN FARMING

## THE BLACK PEARL GARDENS



**Dow Masters/Professional Sustainability**

**2015 Cohort**

Lindsey Von Seggern • Jillian Shotwell • Andrew Zack

Frank Romo • Luiz Roberto Queiroz de Abreu Sodre

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## 1 Introduction

As a part of the Dow Masters/Professional Sustainability Fellow 2015 Cohort, we worked to develop and assist in the success of a new microgreen greenhouse in the basement of The Black Pearl Restaurant called Black Pearl Gardens. Our group's client was Christy Kaledas, a microgreen grower hired by the Black Pearl to transform their basement space into a greenhouse. All of the crops grown will be served at the Black Pearl restaurant and other local businesses, in hopes to both localize the menu further and promote business by advertising sustainability. Fellows worked on and provided recommendations for many different aspects of the project: social media analysis, project development/operations, logistics recommendation, environmental analysis, analysis of the space, growth plan, and financial feasibility. The following report details what we hope can be used as a case study for future urban farmings.

### 1.1 Examples of Urban Farming in Underutilized Spaces

The practice of urban farming has a history of typically existing within and claiming vacant structures, giving them a new purpose. The Black Pearl Gardens (BPG) followed other's examples by reclaiming an underutilized basement space. Close by in Detroit a Christian organization, Central Detroit Christian, acquired an old liquor store, gutted the inside, repaired the roof and floors, and constructed an aquaponics system out of cheap materials<sup>1</sup>. The entire initial investment was relatively low cost, due to the location of the facility in a vacant space and utilization of cheap materials such as 2x4's and pond liners, as opposed to high end plastic or glass tanks. In Chicago another urban farming start-up called The Plant, transformed an old meat-packing warehouse in the middle of a food desert into a productive indoor farm<sup>2</sup>. Over time, The Plant added a beer and kombucha brewery to their operations, which supply their spent grain to the fish as food and excess CO2 for the plants. This expansion of urban farming to value-added products is something that our client at the Black Pearl Gardens plans to model. In London, England, Growing Underground utilizes forgotten underground World War II tunnels lying beneath busy streets<sup>3</sup>. This accessible system allows for Growing Underground's produce to be in very close proximity to London food markets. There are hundreds of examples of various scales of urban

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<sup>1</sup> Central Detroit Christian Community Organization. Retrieved from Central Detroit Christian Website: <http://centraldetroitchristian.org/>

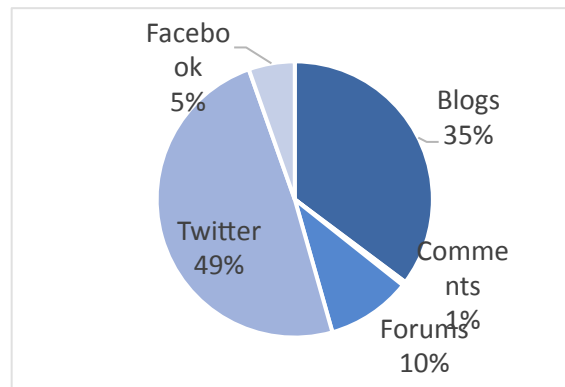
<sup>2</sup> The Plant Explained: A Tour of Chicago's Amazing Vertical Farm. (2012, May 8). *The Huffington Post*.

<sup>3</sup> Roberts, S. (2015, July 3). Growing Underground Farms Greens In Forgotten Tunnels Below London. *Gizmag*.

farming within underutilized spaces, from converted vacant warehouses to an empty room in ones' home or basement<sup>4</sup>.

## 1.2 Social Media Analysis

Social media has been a vehicle where people frequently debate about relevant topics of our day-by-day lives. We evaluated posts from various social media sources in an attempt to find insights about people's thoughts on indoor farming production. The analysis consisted in observing patterns across thousands of posts published by people from across the globe and identifying trending topics related to theme.



**Figure 1** Sources of Posts meeting the Search Criteria

Through a licensed research tool (Forsight Crimson Hexagon from Twitter), we investigated posts from September 15<sup>th</sup>, 2010 to October 10<sup>th</sup> 2015 containing either the word “urban” or “indoor” along with the word “farm” or “farming”. The search retrieved approximately 984K posts mostly from Twitter, but also distributed across various blogs, forums and Facebook.

The data shows an increasing debate surrounding the topic of urban indoor farming, represented by a 31% growth in volume of posts in the analyzed period. During this period, three different spikes can be associated with the topic; the first one in October of 2011 of almost 20K posts, can be associated with widespread campaigning about the urban farming cubic farming techniques. This type of production requires a completely controlled environment, and therefore does not employ any kind of pesticide, fungicide or herbicide in its production. The second spike in posts happened in March 2013, followed the announcement of the largest indoor vertical farm in the US located in the suburbs of Chicago. The last spike happened more recently, in July 2015, about the construction of the largest indoor farm in US, located in Newark, New Jersey. Most of the debate around these topics and many

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<sup>4</sup> Kaufman J, Bailkey M. Farming Inside Cities: Entrepreneurial Urban Agriculture in the United States. (2000). *Urban Tilth*.

others involving indoor farming are associated with the sustainable production of food. This include the more efficient use of resources such as water, land and soil, and inorganic fertilizer as well as the usage of chemicals in agricultural production.

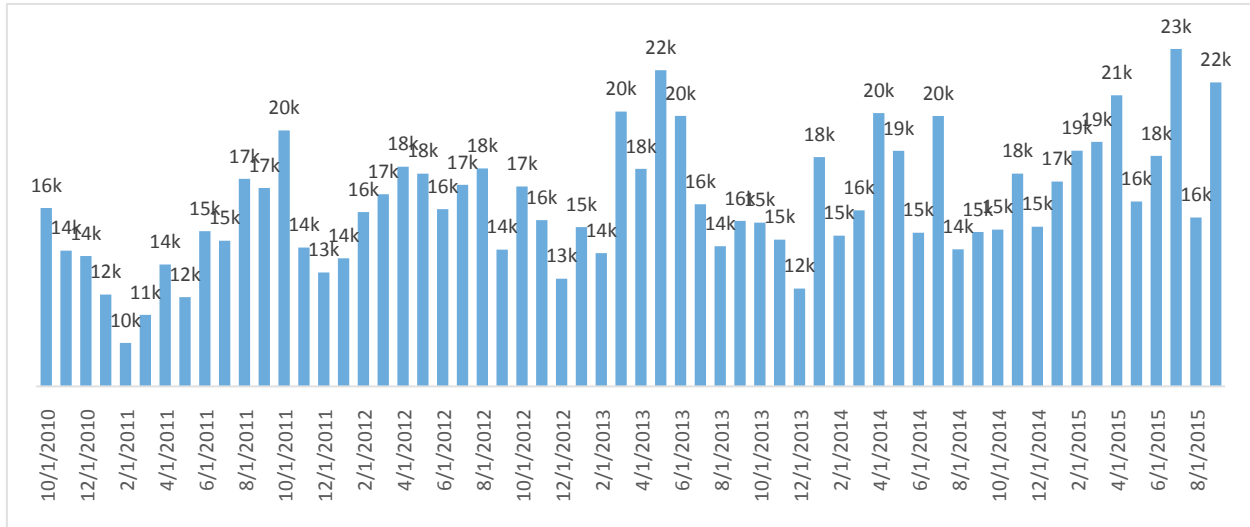


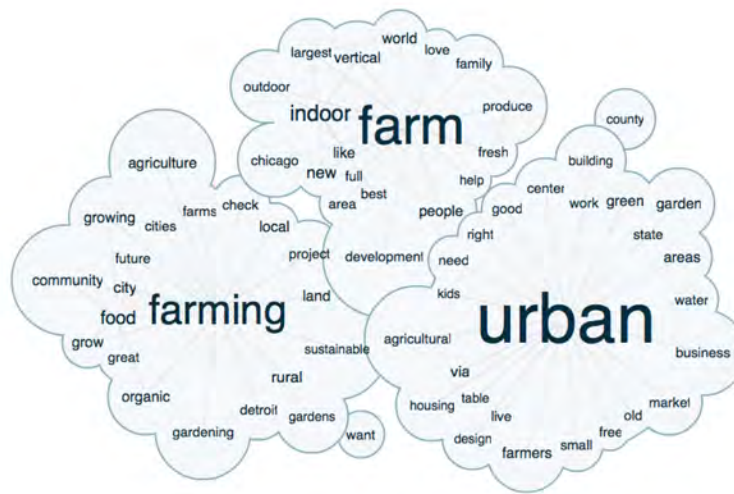
Figure 2 Historical Data on Posts meeting the Search Criteria

In fact, when we take a closer look at a sample of posts and analyze the most frequent words related to indoor or urban farming, we find words like water, organic, sustainable, land and many others that corroborate the findings obtained by analyzing a few different posts on trending topics as described above.



Figure 3 Word Cloud

When analyzing how frequent words are linked to one another, we also find that indoor farming has been considered by many as a source of future community development.



Buzz 6 (Luiz Sodre -7/13) — Clusters from 9/15/10 to 10/3/15

**Figure 4** Word Cluster

## 2 Project Development Summary

### 2.1 History and Overview

When our group first met with our client Christy Kaledas, the now manager at Black Pearl Gardens, she was just beginning to build her space in the basement of The Black Pearl Restaurant. At the time, she was growing microgreens in her home basement, using grow lights bought from a local hardware store with significant success. However, the feasible yield of her basement was beginning to fall far short of filling her increasing client list. The indoor farmer’s space was set up very quickly and was anticipated to be temporary. The lights that she used were inefficient, expensive to run, and broke quickly. She watered every crop by hand with a watering can in order to maintain them, and she was her only employee, apart from infrequent help from her family.

While growing in her basement, Christy Kaledas was supplying to the Black Pearl, Vinology, Prickly Pear, and Argus Farm stop occasionally when her yield exceeded her mandatory orders.. The Black Pearl Restaurant had been interested in beginning their own urban farming project for several months when they began sourcing from our client, and when the two discussed her cramped quarters, they decided to partner. The Black Pearl has unlimited access to as many microgreens as they please, and in return have funded almost the entirety of Black Pearl Gardens’ development in the basement of

their restaurant. Over the past year, this development has included the purchasing of hundreds of growlights, growing trays, harvesting and packaging materials, one full-time garden manager, and transportation costs for all product deliveries. For more information on costs, please find the section on financial research.

In her basement, our client was originally growing Cilantro, Basil, Kale, Arugula, Fennel, Shiso, Dill, Radish, Cress, Spicy Mix (mustard blend), Mild Mix, Amaranth, Broccoli. With the added space and funding from the Black Pearl, Ms. Kaledas was able to expand to what she is growing today, including: basil, kale, broccoli, arugula, mustard green, radish, amaranth, cilantro, mizuna, beet greens, spicy mixed greens, pea shoots, red cabbage, sunflower, and scallions. Our team originally suggested many of these new microgreen items, including scallions and the beet greens based on our Client's specific preferences for her growing space; the crops must have a 12-18 day growing season, must be available in an organic and non- Genetically Modified variety, and must not have deep roots so as not to overwhelm the small tray growing space that they are contained in.

## **2.2 Growing Medium**

Several different growing mediums have been discussed and introduced to the Black Pearl Gardens. However, our client has ultimately chosen to grow soil-based microgreens over other mediums. Research was initially done on the possibility of using Coco Coir Bricks as a soil substitute, however the bricks are much more expensive than soil. In addition, the tightly controlled environment of the basement did not call for all of the features that this coconut-based medium supplied, including specific non-soil based growing trays and a predominantly hydroponics watering system<sup>5</sup>. Soil erosion and leaching were not concerns in our space, and Black Pearl Gardens employees are able to compost and re-use much of the soil for multiple plantings of greens, further discounting the necessity of investing in Coco Coir.

More recently, cellulose strips have been tested in the greenhouse as a medium, as far less cellulose medium is necessary for growth, and many of the garden manager's colleagues have grown in it with much success. However, only one of our microgreen varieties was even mildly successful in this growing medium. We experienced large amounts of mold with the cellulose, mainly because it had very poor absorption of water. All of the tested microgreens, apart from basil, had to be thrown out when

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<sup>5</sup> Meerow A. (1994, December). Growth of Two Subtropical Ornaments Using Coir (coconut Mesocarp Pith) as a Peat Substitute. *Horticultural Science*.



attempted on this medium. It should be noted that although basil was mildly successful on cellulose, it grew significantly better in soil.

### **2.3 Operations and Challenges**

All seeds are purchased from certified organic, non-GMO distributors across the country, including Johnny's Selected Seeds, MV Seeds, Pinetree Seeds, and Todd's Seeds. While seed type is a personal choice based on grower preference, the project manager decided to purchase only non-GMO organic seeds for several reasons. First of all, she felt that her customer base, adventurous eaters concerned about health and local food, would be less enthused by her product if it were not certified organic and non-GMO, which has been supported by several studies on customer perceptions<sup>6</sup>. Second, she has doubts about the relative safety of genetically modified crops, and she did not trust that the seeds were not sprayed with chemicals to help them grow faster. She chose to go with seeds that had a reliable growing time frame, and that she felt most comfortable supplying to her clients.

Several large challenges have occurred in the implementation of Black Pearl Gardens. In the early stages of development, our client had a difficult time finding reliable help for the development and day-to-day operations of the project. It was challenging to recruit volunteers to help with work, as many of those who would like to volunteer likely have to work at the times where activities are being done in the basement greenhouse. In addition, while the Black Pearl is located in a large college town, our client could not find the time nor the platform to advocate for volunteers from the University without additional help. Many students on the University of Michigan campus are a part of volunteer groups and food sustainability organizations, however a marketing or outreach person was needed to inform these student groups about the Black Pearl Gardens and invite these groups to work in the space. Even when one of our team members reached out to these groups, no responses were heard regarding interest in working on the project. While it is unclear why this may be, it is likely because our Client did not have the ability to hire a person to actively seek out volunteers, and did not have the ability to seek out volunteers herself due to time constraints. For those interested in pursuing a similar project, this suggests a need for a more integral marketing and public relations point person when beginning a new project similar to Black Pearl Gardens.

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<sup>6</sup> Yiridoe, E. (2005, March 15). Comparison of Consumer Perceptions and Preference Towards Growing Organic Versus Conventionally Produced Foods: A Review and Update of the Literature. *Renewable Agriculture and Food Systems*.

In addition to volunteer and staffing challenges, Black Pearl Gardens faced many challenges due to its innovative take on agriculture. A local hydroponics company was hired to design and build self-watering tables for the space. However, after multiple companies were hired and subsequently fired, Ms. Kaledas did not find a reliable or experienced company to follow through on the development of a hydroponics system. In addition to her challenges with hydroponic development, Ms. Kaledas experienced similar problems with several contractors when attempting to set up the space for proper drainage, air conditioning, and grow table accommodations. While many of these contractors had substantial experience on general construction, the project manager has begun to believe that many are inexperienced with this type of work. While this should not necessarily deter others from pursuing indoor gardening, it should highlight the importance of finding reliable help when looking to contract out or expand.

One of the most challenging pieces of developing Black Pearl Gardens for our client has been finding a reliable full-time worker. Beyond volunteer support, Christy struggled without having another person to share her long-term vision with. Being the developer, the manager, the grower, and the distributor is arguably a nearly impossible task for one person. There were many weeks in the first several months where the BPG struggled to meet orders, creating additional stress on the business. While she had large plans to continually update the space and eventually expand to a 17-acre farm in Pittsfield Township, these larger projects were put on hold due to the pressing day-to-day work. The project manager hired several part-time employees, however faced a challenge when looking for experienced workers. In September, Kaledas finally hired a full-time worker, Briannon English, with years of experience in sustainable food systems. Since hiring the new garden manager, yields have become steadier, our client has had more time to plan for the future of the gardens, and the 17-acre farm is coming to fruition, and should begin yielding crops for sale in the spring of 2016.

The garden manager has implemented several new methods designed to increase yields, including a technique called stacking. During seed germination, soil trays are stacked on top of each other to lightly compact the soil and allow for roots to take better hold of the soil. This also maintains moisture within the soil and generally allows for faster germination, thus increasing yields and decreasing the growing time of Black Pearl Gardens' microgreens. At this stage, microgreens require no light, and so this technique can decrease grow time to harvest by 1-2 days, while also allowing for more greens to be in the grow space without using up room on non-germinated seeds.

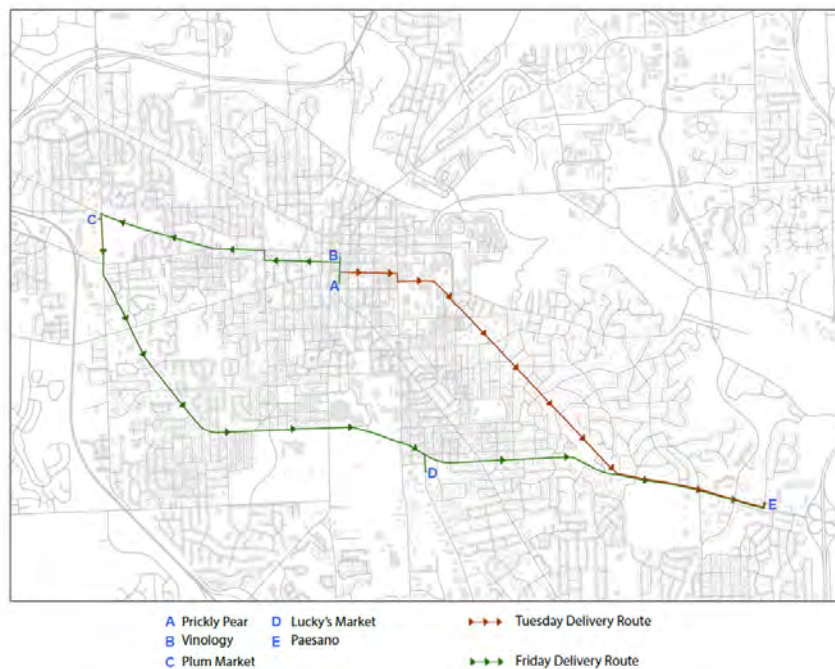
As of October 1, Christy is selling to all of her original vendors, and has added several local grocers and restaurants to her clientele. She is now easily meeting her demand within the basement of The Black Pearl, and has started to seek out new clients for the near future as her self-watering system becomes functional. Briannon English, the new garden manager, has helped our client tremendously with day-to-day gardens operations, as well as with developing a workable vision for the project. They have developed a new logo for the gardens, and are planning on becoming a widely appealing and well known sustainable grower in the Ann Arbor area. In addition, several new and unique projects are being researched for both the Black Pearl Gardens basement microgreen space and the newly purchased 17-acre plot in Pittsfield Township. Among these new research topics include mushroom development, large-scale composting, and entomophagy, or the consumption of bugs as a sustainable protein alternative to meat.

### 3 Black Pearl Gardens Logistics

In order to make the Black Pearl Gardens operation as efficient and economical as possible, we performed a transportation logistics analysis. The goal of this analysis was to review current delivery routes and identify new opportunities for decreasing costs, energy consumption and vehicle miles traveled. The transportation analysis took a variety of factors into account including current delivery schedule, delivery locations, and best available routes based on local traffic and congestion. Incorporating these different variables helped us identify the most efficient way to service all of the Black Pearl Garden's many different clients.

**Figure 5** Optimal Delivery Routes for Black Pearl Gardens Distribution

Using Ann Arbor traffic, and road data we were able to perform a network analysis: a mapping



technique that analyzes all potential routes along the street network to identify the most efficient transportation routes. We first located all of the restaurants and stores serviced by Black Pearl Gardens, then by using the Black Pearl Gardens as the starting point, we calculated the most efficient route to accommodate all store locations on a given delivery day. The map below shows the optimal delivery routes for servicing all Black Pearl Gardens clients on two separate delivery days. The routes produced are considered the optimal cost and energy saving routes because they not only reduce the distance traveled but also the amount of time traveled on each day. All deliveries are made to restaurants on Tuesdays and Sundays of each week, and so this dual route proposal is a feasible and cost-effective change for our client to make.

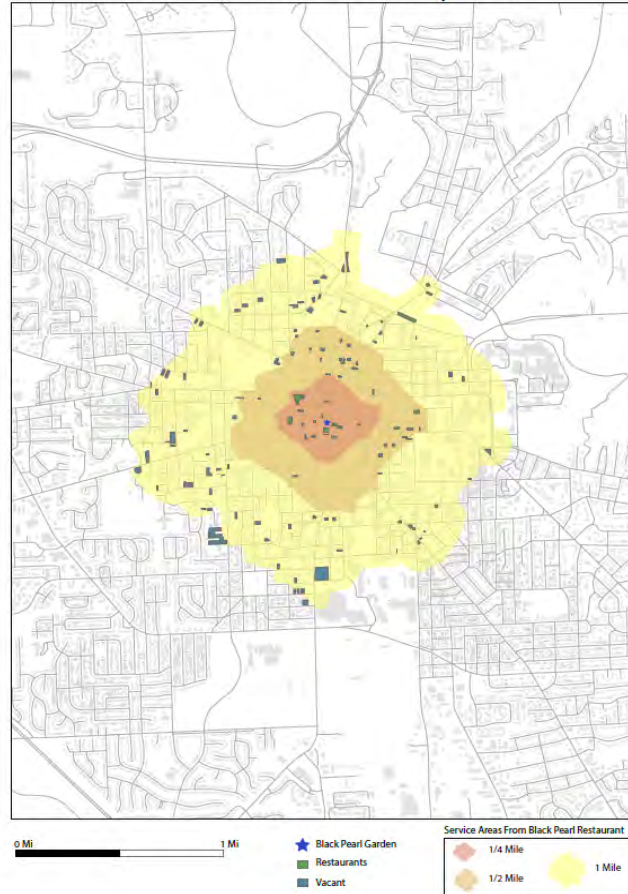
### **3.1 Black Pearl Gardens Expansion**

The Black Pearl Gardens is quickly growing and now serves grocery stores and local restaurants all around the City of Ann Arbor. As the operation continues to grow, it is important to consider the possibility of expansion throughout the city. We used City of Ann Arbor parcel data to help identify potential lots/parcels for future expansion. This is the initial starting point of a larger analysis that will identify the best potential parcels for investment and expansion of the Black Pearl Gardens operations. The locations on the map were identified using a suitability analysis which identified all parcels that either had a restaurant of potential interest on site, or a building classified as vacant by the city planning office. The goal of this analysis is to find commercial properties similar in size to the Black Pearl Gardens current operating space and identify future locations that can be transitioned into similar worksites in the City of Ann Arbor. As this project was just being pursued in the late summer and fall months, our group was unable to analyze information from this venture.

Another potential source of expansion for the Black Pearl Gardens is a nearby farm located near the City of Ann Arbor and Pittsfield Township border. The 17 acre farm is located in South Ann Arbor and includes one structure on each parcel. These farmland areas currently have two residential structures on each parcel and are allocated primarily for agricultural purposes. This means that the Black Pearl Gardens can expand its farming operations to the site immediately without any impedence from city government.

Our client has also expressed interest in adding a commercial structure on the property to use as a restaurant, indoor growing space, and a space for educational agriculture activities. In order to do so, a zoning variance would need to be acquired from local city government. It is very possible that the two parcels could be rezoned to be included in the nearby "commercial-agricultural" zone. If granted a

zoning variance, the Black Pearl Gardens could potentially add commercial structures on the land where they could sell their product.



**Figure 6** Potential Locations for Expansion

Although the current zoning ordinance does not permit commercial-agriculture practices on the property, it is very possible that the Black Pearl Gardens can proceed with their future plans if they are approved for a zoning variance from the township. Expansion to the Pittsfield Township farm is a promising opportunity for the Black Pearl Gardens with a great amount of potential to increase the overall capacity and economic value of the operation. However, in order to realize the full potential of this site our client might need to work with the local government to get specific approval for commercial uses.

## 4 Evaluation of BPG's Environmental Impact

### 4.1 Overview of Environmental Impact

Black Pearl Gardens currently grows microgreens exclusively in an indoor ‘greenhouse’ that receives no natural light. Given BPG’s relatively unique agriculture techniques, we decided to measure the company’s impact on the environment. While BPG may influence the environment in many ways, for this analysis we chose to focus exclusively on electricity use for grow lights and water use for irrigation. This excludes other potential environmental impacts such as transportation, packaging and disposal of soil, electricity used in the growing process other than lighting (fans, air-conditioning, refrigeration), packaging of microgreens.

Instead of natural light, BPG uses over 500 11-watt light bulbs made by a company called TotalGrow that run on timers set to leave the lights on for 12 hours per day. For irrigation, BPG uses several different techniques including pumping water through a hose from 5-gallon buckets, and submerging perforated trays of soil in larger water containers. We measured the energy and water use of the BPG ‘greenhouse’ to examine how the environmental impact of growing in a local basement greenhouse compares to alternative means of growing similar vegetables.

#### **4.2 Energy Benchmarks**

Little data is available on the amount of energy and water involved in growing microgreens conventionally, so we used the water and energy inputs for growing lettuce as a benchmark. Previous research has estimated that it takes 0.14 kilowatt hours (kWh) to produce one pound of head lettuce through conventional farming in Arizona (where a large portion of the United States lettuce production occurs) with a standard error of 0.01 kWh<sup>7</sup>. Yield per square-meter can be greatly improved through hydroponic farming in a greenhouse, but it is estimated that this type of farming results in an almost 100 time increase in energy use to 11.3 kWh (standard error = 1.4 kWh).

#### **4.3 Energy Use at Black Pearl Gardens**

To measure the energy use in BPG, two Kill-A-Watt energy monitors were used to estimate how much energy is required to grow one pound of microgreens. Though lighting is not the only source of energy consumption in BPG’s operations (they also use air-conditioning in the summer and have several fans running to reduce the risk of mold year-round), given the relatively low wattage of the BPG’s electric fans, and the fact that their air-conditioning is only running during a short period in the summer,

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<sup>7</sup> Lages Barbosa, G., Almeida Gadelha, F. D., Kublik, N., Proctor, A., Reichelm, L., Weissinger, E., Wohlleb, G. M., Halden, R. U. (2015). Comparison of Land, Water, and Energy Requirements of Lettuce Grown Using Hydroponic vs. Conventional Agricultural Methods. *International Journal of Environmental Research and Public Health*, 12(6), 6879–6891.

it was assumed that lighting accounts for the large majority of BPG's energy use, and therefore it was the only part of BPG's energy consumption measured in this study.

Two readings were taken from each energy meters, resulting in four estimates of weekly energy use: 959, 846, 1006, and 844 kWh/week. The average estimate is 914 kWh/week (standard error = 82 kWh/week). BPG produces 57 pounds of microgreens in a typical week, which results in an estimate of 15.9 kWh per pound of microgreens (standard error = 1.4). This energy-use estimate is on the same order of magnitude of the amount of energy required to grow in a hydroponic greenhouse, but significantly higher than the energy required to grow conventionally.

#### **4.4 Transportation Energy**

One benefit of growing indoors in Michigan is that very little energy is used to transport the greens after they are cut. However, transportation accounts for a relatively small amount of energy relative to the amount used in growing either indoors or in a hydroponic greenhouse. The majority of lettuce production in the United States occurs in Arizona and Southern California. Estimates vary, but the average amount of energy required to transport one pound of vegetables the approximately 2,100 miles from the Southwest to Michigan is approximately 1 kWh.

Adding 1kWh to the estimated energy used in hydroponic greenhouse farming brings the total to 12.3 kWh compared to 15.9 kWh at BPG.

#### **4.5 Energy Cost**

BPG's growing techniques therefore use far more energy than conventional farming and approximately 30% more energy than hydroponic farming even when only counting BPG's grow lights and ignoring all other types of energy consumption. Even for a relatively small operation like BPG, the cost of this energy can be significant. On average, energy in Michigan costs 11 cents per kWh<sup>8</sup>. At this price and at the estimated rate of 914 kWh/week, BPG will spend \$5,200 on electricity for grow lights per year.

#### **4.6 Water Benchmarks**

Again, since benchmarks for water-use in conventional or hydroponic microgreen production are difficult to find, we used water-use in lettuce production as a substitute. In Arizona, where a large

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<sup>8</sup> U.S. Energy Information Administration—Electricity Data Browser. Retrieved from <http://www.eia.gov/electricity/data/browser/>

proportion of all American lettuce is produced, it is estimated that a hydroponic greenhouse uses 2.40 gallons of water to produce one pound of lettuce (SE=0.46 gal.), and conventional farming uses 30 gallons/pound (SE = 3.0)<sup>9</sup>.

#### **4.7 Water Use at BPG**

Due to the irrigation system in use at BPG, it was difficult to accurately measure the amount of water used. Instead BPG employees were asked to track water use in a week and estimate the total amount used that week. BPG employees estimated that two five-gallon buckets were used for each irrigation session, and that they watered the microgreens five times per week for a total of 50 gallons/week. Since that 57lbs. of microgreens in a typical week, this works out to 0.9 gallons of water to produce one pound of microgreens. This is only 3% of the amount of water used in conventional lettuce production and under 40% of the water used in hydroponic farming.

#### **4.8 Conclusion on Environmental Analysis**

It is difficult to conclusively determine which of the three agriculture techniques examined here has the smallest environmental impact, though there is no clear evidence that BPG is significantly more sustainable than alternative foods grown using conventional techniques. While BPG has the highest electricity-use of the three techniques, it also uses a significantly smaller amount of water. Electricity is a major cost for BPG, and there may be ways to adjust the lighting setup that will reduce costs and lower electricity use to the point where it is roughly equivalent to hydroponic lettuce production. These results should be interpreted with caution however, since reliable water and energy benchmark estimates for conventional microgreen production do not exist.

### **5 Analysis of the Space**

#### **5.1 Efficient and Optimal Space for Urban Farming**

Since The Black Pearl Gardens began in the basement of Christy Kadelas's house, soon there was pressure for more space and the business transitioned from Christy's basement to the basement of the Black Pearl Restaurant. The basement of the restaurant has 6 times the capacity of Christy's basement, with dimensions 40ft by 20ft. Our client was able to transform an underutilized space found within the

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<sup>9</sup> Lages Barbosa, G., Almeida Gadelha, F. D., Kublik, N., Proctor, A., Reichelm, L., Weissinger, E., Wohlleb, G. M., Halden, R. U. (2015). Comparison of Land, Water, and Energy Requirements of Lettuce Grown Using Hydroponic vs. Conventional Agricultural Methods. *International Journal of Environmental Research and Public Health*, 12(6), 6879–6891.



urban fabric into a productive farm. Repurposing and breathing new life into underutilized or vacant spaces within a city is a sustainable way to create vibrant, strong, and healthy urban communities.

## **5.2 Challenges of a Found Basement Space**

The Black Pearl Gardens is able to maximize the current space with growing trays and racks, but some aspects of the found space are not ideal for the business. Our client wants to invite the public into the business through tours and education, teaching the public about the value of fresh, good, and local foods. Currently, it is not possible to bring say 20 children and their teachers down into the growing room, which is not in a publicly accessible space. Public access to the growing room of the Black Pearl Gardens is essential to provide education to others, but given the current space it is not feasible.

Another challenge of operating in the BPG's current space is that there are no windows, and this creates issues with ventilation and humidity. Growing food inherently requires higher than normal room levels of humidity, around 50-60% relative humidity compared to 35-45% in a home or office. Any introduction of water in this windowless space increases the humidity levels and Christy has struggled to keep the percentage in the optimal range, reaching levels of 70% or more. Since the growing trays need water in order to thrive, The Black Pearl Gardens has been trying to find efficient ways to water all of the trays without introducing standing water situations, as is typical in hydroponic systems. Temporary solutions such as multiple box fans and dehumidifiers have attempted to reduce humidity but permanently improving ventilation requires significant financial investment. There is a possibility of cutting a hole through the ceiling which reaches outside air at the sidewalk level in front of the entrance to the restaurant, but this requires major construction and disruption to the restaurant as well as to Christy's current crops.

Hardly ever does a found space function in an ideal way, as if the space was designed exactly for this purpose. Spending the capital up front can transform the space to suit specific needs, but working within the given constraints saves considerably on upfront costs. The Black Pearl Gardens did minimal transformation to the basement including, cleaning, painting, and installing plumbing and electrical systems. BPG's minimal investments in infrastructure allows them to move to another space as they grow without losing significant financial investments.

## **5.3 Improving the Current Basement Space**

As mentioned above, there are ways in which to improve upon the current basement space. Ventilation can be increased with addition of more box fans or punching an opening to the outside air. A

new ventilation system, in conjunction with the dehumidifier and air-conditioning currently in use, would control humidity levels more effectively. The greatest area for improvement in the current space is in the irrigation methods. The task of watering the trays is the second most time-consuming task after harvesting the microgreens. Currently, each tray is watered individually, but setting up a system where all of the trays on one rack can be watered simultaneously significantly reduces the amount of time spent. Further, multiple racks could be ganged together, depending on the differing watering needs between different varieties of microgreens.

However, a system where all of the trays on one rack are connected by draining from the top to the bottom may require a good amount of sitting water. Over the summer, BPG attempted to set up a hydroponics irrigation system, but the job was halted and determined of lesser importance at the time. BPG is still very interested in improving irrigation techniques and are looking at options which are less intrusive on environment and comfort in the basement space. Still using the same logic as the hydroponic systems, setting the smaller trays into larger trays which drain from the top shelves of the rack to the bottom, BPG then needs to introduce water supply to a rack and collect the excess water at the bottom for reuse on other racks. Eliminating the standing water, and reusing water not absorbed by the trays is a sustainable way to reduce the total amount of water used.

This system however does run the risk of migrating disease from one tray rack to another. One of our group member's has had experience with this while volunteering at Central Detroit Christian's Farm and Fishery over the summer 2015. Disease began in one plant and because every plant in the aquaponics farm shares the same recycled water, all plants became effected. Early detection of disease, infection, or pest presence through regular plant inspection is the best way to prevent disease spreading into the entire system<sup>10</sup>. A simple removal of the infected plant will stop the disease from migrating.

#### **5.4 Goals of the Space**

The Black Pearl Gardens strive to make a positive impact on the Ann Arbor community beyond providing fresh food. Goals include giving tours and providing education to the public through hosting classes and community dinners. The constraints of the current location do not allow easy access for the public. This is one among many reasons The Black Pearl Gardens is moving part of the business out to a

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<sup>10</sup> Somerville, C., Cohen, M., Pantanella, E., Stankus, A., & Lovatelli, A. (2014). Plants in Aquaponics. In *Small-Scale Aquaponic Food Production: Integrated Fish and Plant Farming* (pp. 83-102). Rome: Food and Agriculture Organization of the United Nations.

17 acre farm on the edge of Ann Arbor. This farm has always been in the business's 5 year plan, Christy needed to get the business grounded, producing, and successful before a more significant financial commitment. The Black Pearl Gardens also needed time to remediate the overworked and nutrient lacking soil. Christy has been composting all of the used trays out on the farms, introducing very nutrient rich soil to the landscape. With this new farm, which is historically the Geddes Farm in Ann Arbor, the Black Pearl Gardens has goals to grow larger crops on the land in hoop houses, have livestock such as chickens, hogs, goats, etc., host Farm to Table events such as themed, celebratory, and holiday dinners, and have productive space for tours and educational events.

### **5.5 New Barn and the Farm**

The majority of the farm will be dedicated to hoop houses and space for livestock, but a new barn will be built in order to host events and educational activities. This barn also will have space for fermentation and possibly indoor growing space if the demand cannot be met in the existing basement of the Black Pearl Restaurant. The barn will have a large reception and gathering area, large kitchen/prep area, stone oven, market area for selling of Black Pearl Garden's products, and necessary office and storage space. BPG will utilize the market area to sell fermented products, microgreens, and traditional crops grown in the hoop houses. Because this is new construction, the barn and farm as a whole can be designed for optimal space and growing capacity. Organization and access will be fore fronted to accommodate the education of the community, but not be overshadowed by the importance of the farm to function properly in order to maintain the highest crop yields. The new barn will ideally be constructed with reclaimed wood from old barns which are cited for demolition. This is not only sustainable and cost effective, but will give a desired overall aesthetic of imperfect, old, and textured wood, as opposed to new and flawless wood.

The accompanying image is a section through a proposal for the barn created for this report. The overall form is reminiscent of traditional barns with modifications for a 72 degree roof angle which is the optimal tilt for solar panels in Ann Arbor, Michigan. Also, offsetting the roof planes creates a row of windows at the top of the barn which is continued at different levels and heights throughout and in the basement, creating natural ventilation throughout the barn.



**Figure 7** New Barn Project Proposal

### 5.6 Future Expansion into Hydroponics/Aquaponics

A hydroponic system was not ideal for the space in the basement of the Black Pearl Gardens because of ventilation and humidity concerns. However the new barn can have a space specifically designed for hydroponic growing conditions. Hydroponics is a growing method without soil. Roots are either suspended/floating in water or supported with grow media, such as rocks or clay pebbles. The most significant benefit of hydroponics is water conservation, hydroponics uses less than 10% of the water used in traditional agriculture<sup>11</sup>. This is because the water is constantly recirculated and significantly less is lost due to evaporation. Hydroponics is also typically performed in a controlled indoor environment which allows for year-round access to organic, pesticide free, and fresh daily produce which might not be readily accessible in urban areas, especially during winter months<sup>12</sup>. Localized production reduces the intensive transportation costs associated with traditional farming,

<sup>11</sup> Chalmers, DVM, G. A. (2004). *Aquaponics and Food Safety*. Lethbridge, Alberta.

<sup>12</sup> *Aquaponics FAQ*. (2015). Retrieved from Endless Food Systems: <http://www.endlessfoodsystems.com/faq.html>

whether that cost is placed upon consumers in the form of higher prices or placed upon future generations in external costs adding to carbon emissions<sup>13</sup>.

Aquaponics is the introduction of aquaculture into hydroponics. Simply, the waste products from the fish in aquaculture, typically tilapia, are used to fertilize the plants. The symbiotic relationship reduces deficiencies in both food production systems<sup>14</sup>. In aquaculture, toxic levels in the tank rise due to the waste build up, requiring a re-circulation of water. In hydroponics, the roots constantly need nutrient uptake to survive. An aquaponic growing system works by filtering the nutrient rich waste from the fish tanks and using it to fertilize and irrigate the hydroponic beds. The plants filter out the ammonia, nitrate, nitrites, and phosphorus, cleaning the water and allowing it to recirculating into the fish tank<sup>15</sup>. The recirculation of water makes a closed loop system except the food to feed the fish and the energy powering the pumps (and grow lights if it is an indoor shaded system).

### **5.7 Benefits of Hydroponics/Aquaponics**

A big question surrounding aquaponics is how green it is when accounting for the energy needed to power the pumps and growing lights. All of the energy needed for an aquaponics system is electrical, so alternative energy systems such as solar, wind, and hydroelectric can provide all of the power for an aquaponic farm.<sup>16</sup> Traditional farms use fuel and/or petrochemical intensive fertilizers which are generally produced at great distances from the farm, where electrical energy can be produced locally on site. There is a stigma that since aquaponics are normally used in indoor controlled environments, there are huge energy bills. Depending on the system, what climate it is in, and the fish and plants involved, energy usage varies. A greenhouse utilizing natural sunlight and heat would only need electricity for the pumps, thus using relatively little energy. Typically the water needs to be heated for both the fish and the plants, and because the water is constantly recirculated, once it is warm, there is little reheating necessary. Warm roots make happy plants, therefore the air temperature of the room doesn't need to be as warm, saving energy costs of reductions in heating the air in entire greenhouse during winter months.

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<sup>13</sup> *Aquaponics FAQ*. (2015). Endless Food Systems

<sup>14</sup> *Aquaponics FAQ*. (2015). Endless Food Systems

<sup>15</sup> Diver, S., (2006). *Aquaponics-Integration of Hydroponics with Aquaculture*. National Sustainable Agriculture Information Service. Retrieved from:

<http://www.backyardaquaponics.com/Travis/aquaponic.pdf>

<sup>16</sup> *Aquaponics FAQ*. (2015). Endless Food Systems

Having a controlled environment creates a versatility in the system. Wide varieties of crops can be grown, such as herbs, spices, vegetables, and fruits. Currently, root vegetables is a major food group which is unable to be grown. Leafy greens are the most popular crops in aquaponic systems<sup>17</sup>. Growers claim there is no difference in food taste, even saying it is better because of the absence of fertilizers and other harmful chemicals. However, the push back comes when accepting a carrot grown in water as opposed to traditionally in soil. Capitalizing on the versatility of the system, specialty markets are a great use of aquaponics. Items can be grown to meet the local demand of exotic and/or cultural products. For example in Alberta, Canada, there is a need for hot weather crops such as bell pepper but their location is too far north to be able to grow peppers traditionally<sup>18</sup>. In Michigan and Washtenaw County, aquaponic farms can increase the length of the growing season and provide fresh tropical fruits during the winter freezes<sup>19</sup>. However, this new access to exotic food grown locally can be unsettling for many people who aren't used to it.

### **5.8 Criticisms of Hydroponics/Aquaponics**

As mentioned above, the main criticism of aquaponics is the acceptance of food from nontraditional sources. Consumers are weary of food grown without soils and food which is fertilized by fish effluent, mainly because the idea is foreign to them<sup>20</sup>. Another main criticism of aquaponics is the food used to feed the fish. In commercial aquaponics, the food feed to the fish livestock is typically fish food pellets as opposed to flakes<sup>21</sup>. These pellets are made from smaller bait fish with were grown specifically to be made into fish food. This unsustainable practice is not a core problem of aquaponics but of aquaculture, however aquaponics has been unsuccessful in finding a more sustainable practice<sup>22</sup>.

In general, day to day labor costs are low, but labor for repair and maintenance can come at a significant financial cost. Aquaponic systems can be more complicated than small-scale agriculture, where correct set up, monitoring, maintenance, and pH balance, are all necessary for growth. However, once the system is functioning, day-to-day activities are limited to providing fish with their food and

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<sup>17</sup> Chalmers, DVM, G. A. (2004). *Aquaponics and Food Safety*. Lethbridge, Alberta.

<sup>18</sup> Chalmers, DVM, G. A. (2004). *Aquaponics and Food Safety*. Lethbridge, Alberta.

<sup>19</sup> Widener, *Aquaponics: A New Source for Detroit and Michigan*.

<sup>20</sup> Clark, M. (2012, August 1st). *Aquaponics Skeptic Turned Believer Hopes to Bring Growing Method to Homes and Urban Areas Across America*. SeedStock

<sup>21</sup> *Aquaponics FAQ*. (2015). Endless Food Systems

<sup>22</sup> Clark, M. (2012, August 1st). *Aquaponics Skeptic Turned Believer*

making sure your plants are in optimal growing conditions (temperature, light values)<sup>23</sup>. Since aquaponics is at a smaller scale than traditional farming, there aren't developed tools and machinery to help make harvesting of the crops easier. One of the most common crops in aquaponics are microgreens, which require hand cutting and packaging, which can be incredibly time consuming if available hands are limited and the yields are large. This delicate hand labor can be seen as a positive or negative trade off from the quick and efficient diesel powered turbines on commercial traditional farms. Critics also question why the majority of the materials used in an aquaponics systems are not sustainable. Most systems use components which are made of plastic, metal, PVC pipe, and synthetic glue<sup>24</sup>.

### **5.9 Conclusion for Efficient Space**

The Black Pearl Gardens transformed an underutilized space, their basement, into a productive urban farm. Given their constraints with using a found space, the ventilation, humidity, and access/organization posed challenges. The current space is maximized with growing trays, but is not able to accommodate other functions such as tours and education to the public, which is a goal of The Black Pearl Gardens. Also in the current space, irrigation is a challenge because having sitting water in the basement raises the humidity too much. Transitioning to hydroponics will reduce the time it takes to water all of the plants, but will raise the humidity. The Black Pearl Gardens also owns 17 acres of land right on the edge of Ann Arbor and is expanding out to it within the next year. On this land, a new barn is proposed which will accommodate all of The Black Pearl Garden's goals: sustainable urban farming, public access/tours, Farm to Table events, and servicing the local community. The Black Pearl Gardens has their ambitions in the correct spot in order to beneficially improve the local community through sustainable and organic means. Exposing the public to the value and importance of good and local foods is imperative.

The locality of the food is necessary as urban areas are becoming underserved and neglected food deserts, consisting of chain fast food restaurants and party/liquor stores. Methods such as hoop houses, vertical farming, hydroponics, and aquaponics, help to bring fresh food into urban areas where availability of space can be hard to find. However all aspects discussed must be considered. Utilizing a vacant space in urban areas helps to densify the city core and provides fresh produce, but working in

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<sup>23</sup> *Aquaponics FAQ*. (2015). Endless Food Systems

<sup>24</sup> *Aquaponics Borneo*, (2001). *Is Aquaponics Truly Sustainable?*

those conditions requires sacrifices. Renovating or building new structures to accommodate urban farming is costly and is more damaging to the environment than utilizing something which is already there<sup>25</sup>. The BPG successfully transformed a vacant basement into a function farm with minimal to no renovations. Their new barn out on the 17 acre farm will have large environmental impacts during construction but it will be built with sustainable materials, will produce energy with solar panels, and give back to the community with food production. Weighing the costs and benefits is personal to each urban farmer in order to choose what type of space and growing system (soil vs hydro/aquaponics) fits best with their values.

## **6 Financial Analysis**

### **6.1 Analysis Overview**

The objective of the financial analysis is to evaluate the profitability of an indoor farming business. We use Black Pearl Gardens as a case for understanding, assessing and analyzing the underlying factors that impact the profitability of such business. In this section, we do not disclose any confidential and financial information about Black Pearl Gardens. All the analyses presented are based on a hypothetical scenario that takes some production data presented by the client as benchmark while using all of the financial data from publicly available information from the marketplace. Black Pearl Gardens has received the real analysis of its business.

We developed a pricing and profitability model to assist managers to make well informed decisions in regards to the price and costs of their products. The first comprises the analyses of revenues and costs per product package. Fixed costs are allocated to each product and along with variable costs assist managers to set up the price of each of these products through the cost plus markup methodology. In the profitability model, costs and revenues are analyzed on aggregated basis, allowing the calculation of monthly operating profits. In addition, the model calculates aggregated investment numbers and therefore, the payback period, or the number of months the investor will be able to get its invested capital back.

### **6.2 Business Setting**

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<sup>25</sup> Zolfagharian, Nourbakhsh, Irizarry, Ressang, & Gheisari, (2012). *Environmental Impacts Assessment on Construction Sites*.



As described above, Black Pearl Gardens is currently located in a room in the basement of Black Pearl restaurant. The business consists primarily of growing microgreens in trays filled with soil that in turns are laid on racks that are spread across the room. Due to nature of the business, large and powerful LED lights are needed to enable the growth of the plants<sup>26</sup>. These lights are usually the bulk of the investments in operations when setting up an indoor farming business and leaving any investments in real estate aside. Automated irrigation can also represent a relevant chunk of initial investment, however this is not the case for Black Pearl Gardens, which still relies on manual irrigation.

In our model we consider the hypothetical production of microgreens in 360 growing trays, which would require 36 growing racks to support them and the installation and operation of 864 growlights. This setting follows the same proportion of Black Pearl Gardens despite not being the same numbers. While the company grows different crops at different amounts, our model distributes the 18 different varieties it produces evenly across the 360 trays. This leads to 20 trays producing each crop variety. These varieties present different maturity dates and productivity ratios, as shown illustrated in the table below.

**Table 1** Production and Packaging Data per Crop

<b>Crop</b>	<b>Estimated Production per Tray [oz]</b>	<b>Days to Maturity</b>	<b>Package Size [oz]</b>
Cilantro	3	18	2
Bull's Blood	2	18	2
Kale	6	7	2
Broccoli	6	7	2
Arugula	6	7	2
Mustard	4	7	2
Amaranth	2	9	2
Radish	5	5	2
Mizuna	5	7	2
Basil	5	20	2
Pea Shoots	7	22	2
Scallion	2	10	1
Lentil	6	22	6

<sup>26</sup> Yeh, N, Chung, J-P. High Brightness LEDs – Energy Efficient Lighting Sources and Their Potential in Indoor Plant Cultivation. *Renewable and Sustainable Energy Reviews*.

Sunflower	7	7	2
Red Cab	4	10	2
Pac Cho	4	10	2
Tokyo	3	12	2
Chard	2	12	2

Source: BPG

Black Pearl Gardens uses only one type of package when commercializing its products. The same size package can carry different/weight of microgreens depending on their densities. The amount of microgreens sold in each package is described in the table below.

BPG purchases the seeds of microgreens in local shops. The cost incurred with these purchases represents most of the variable costs associated with the production. Soil is an additional asset purchased on variable basis to support production. Fertilization of crops is done with egg shells and are obtained at no direct costs, and thereby is not being considered in our model.

Among operational fixed costs are water, power and labor. The operations management cannot exactly discriminate power and water costs from the restaurant, leading to inaccurately measurements on how these costs could increase as production increases. This is the reason why these costs are treated as fixed in our model. The analysis considers the employment of two full-time employers, in line with standards of the client.

Finally, BPG incurs the cost of packaging and delivering the products to its clients. The model assumes 15 miles on average delivery per day. A more efficient manner of delivery is extensive discussed above.

### 6.3 Financial Assumptions

Our financial analyses takes into consideration the period following the clearing, cleaning and renewal of the room being used in production. Therefore the initial investment considered are those strictly associated with the production of microgreens, the trays, racks and lights, described in the table below:

**Table 2** Total Initial Investments for an Indoor Farm

Item	Units	Unit Cost	Total Cost
Light Bulbs	864	\$ 50.00	\$ 43,200.00
Growing Racks	36	\$ 109.00	\$ 3,924.00

Growing Trays	360	\$ 1.40	\$ 504.00
<b>TOTAL</b>			<b>\$ 47,628.00</b>

Source: BPG; Group Analyses

The price of seeds used in our model were obtained from a local store, the same from which Black Pearl Gardens usually buy its seeds. We estimated an average amount of seeds per tray and were able to determine the average cost of seeds per tray, described in the next table. The amount of soil applied to each tray was fixed and estimated at a cost of \$ 0.21 per tray.

**Table 3** Seed Price and Usage per Crop

Crop	Price per Seed Package [\$]	Size of Seeds	Seeds/Tray [#]	Seeds Cost/Tray [\$]
Cilantro	\$16.00	Large	1,400	\$0.62
Bull's Blood	\$20.55	Large	1,400	\$0.82
Kale	\$23.35	Small	2,200	\$0.34
Broccoli	\$13.80	Small	2,200	\$0.52
Arugula	\$22.65	Small	2,200	\$0.20
Mustard	\$15.10	Large	1,400	\$2.82
Amaranth	\$28.70	Small	2,200	\$0.11
Radish	\$43.10	Large	1,400	\$2.01
Mizuna	\$35.40	Small	2,200	\$0.39
Basil	\$28.40	Small	2,200	\$0.23
Pea Shoots	\$6.45	Large	1,400	\$2.91
Scallion	\$35.70	Small	2,200	\$0.39
Lentil	\$11.50	Large	1,400	\$0.98
Sunflower	\$10.05	Large	1,400	\$1.68
Red Cab	\$39.95	Small	2,200	\$0.88
Pac Cho	\$70.30	Small	2,200	\$0.94
Tokyo	\$32.10	Small	2,200	\$1.96
Chard	\$99.40	Large	1,400	\$2.63

Source: Johnny Seeds; Group Analyses

The fixed costs are described in the table below. As stated earlier, the operations currently employs two full time employees, making up most of the costs associated with production.

**Table 4** Operating and Selling Fixed Costs

<b>Item</b>	<b>Units</b>	<b>Unit Cost</b>	<b>Total Cost</b>
Power	1	\$120.00	\$120.00
Water	1	\$50.00	\$50.00
Labor [employees]	2	\$2,000.00	\$4,000.00
Transportation [miles] (15 miles x 30 days)	450	\$0.57	\$256.50
<b>TOTAL</b>			<b>\$4,306.50</b>

Source: BPG; Group Analyses

#### **6.4 Pricing Model**

The pricing model allow us to better determine the price based on the cost structure of each microgreen variety. In the current model, we set up prices at a markup of 20% over the cost per package. The major cost of most microgreens is labor, classified under fixed cost. The major factors affecting variability among the suggested prices of the different crops are productivity, days to maturity, package size and cost of seeds.

Bull's blood is the less productivity variety and one with the longest days to maturity. Since we have allocated fixed costs equally across trays – we assumed each tray requires the same amount of work, water and power – this each package of Bull's blood ends up absorbing a greater amount of fixed costs, leading to a higher cost structure. Cilantro follows the same pattern. Lentil also has longer days to maturity, however while it is a lot more productivity than Bull's blood and Cilantro, its package size is also a lot larger. Lentil becomes the most expensive product per package given these facts. A lot of the mid-priced products, such as Mustard, Tokyo and Chard, falls in this range because of the higher price of its seeds than the remaining.

Overall, most of the products fall in the \$1.50 to \$4.60 range. This range may be perceived as small but it is more than twice the minimum value (\$3.10 vs. \$1.50) and still is a lot. The current model does not take into consideration demand characteristics such as volume, preferences, willingness-to-pay, etc. Nevertheless, our analysis suggest that the varieties be priced differently to account for the

different production factors and cost structure. Failing to discriminate prices can lead to a profit maximization model that suggests the production of only the most productive, early producer and cheaper variety.

**Table 5** Suggested Price per Crop Considering a 20% Profit MarkUp

Crop	% of Price				Unit Cost	Profit Margin	Profit	
	Package Price	Seeds	Soil	Fixed Costs			per Package	Price
	Cilantro	3%	6%	2%			69%	\$5.70
Bull's Blood	2%	8%	2%	68%	\$8.64	20%	\$2.16	\$10.80
Kale	13%	7%	4%	56%	\$1.37	20%	\$0.34	\$1.71
Broccoli	13%	10%	4%	53%	\$1.43	20%	\$0.36	\$1.79
Arugula	14%	4%	4%	58%	\$1.32	20%	\$0.33	\$1.65
Mustard	6%	35%	3%	36%	\$3.18	20%	\$0.79	\$3.97
Amaranth	4%	2%	4%	70%	\$4.24	20%	\$1.06	\$5.30
Radish	9%	33%	3%	34%	\$1.94	20%	\$0.48	\$2.42
Mizuna	11%	8%	4%	57%	\$1.62	20%	\$0.40	\$2.02
Basil	5%	2%	2%	71%	\$3.69	20%	\$0.92	\$4.61
Pea Shoots	5%	18%	1%	56%	\$3.70	20%	\$0.92	\$4.62
Scallion	7%	6%	3%	64%	\$2.58	20%	\$0.64	\$3.22
Lentil	2%	8%	2%	69%	\$10.44	20%	\$2.61	\$13.05
Sunflower	12%	24%	3%	41%	\$1.59	20%	\$0.40	\$1.99
Red Cab	7%	12%	3%	58%	\$2.82	20%	\$0.71	\$3.53
Pac Cho	6%	13%	3%	57%	\$2.85	20%	\$0.71	\$3.57
Tokyo	4%	21%	2%	53%	\$4.96	20%	\$1.24	\$6.20
Chard	2%	26%	2%	49%	\$7.99	20%	\$2.00	\$9.99

Source: Group Analyses

### 6.5 Profitability Model

Our profitability model aggregates revenues and costs, resulting in the operating profit of the business. For the calculation of operating profit, we are ignoring depreciation costs for the purpose of calculating the total payback period. Additionally, in this cash-flow analysis we assume everything being produced is being sold and paid within the same period, both on revenues and cost side.

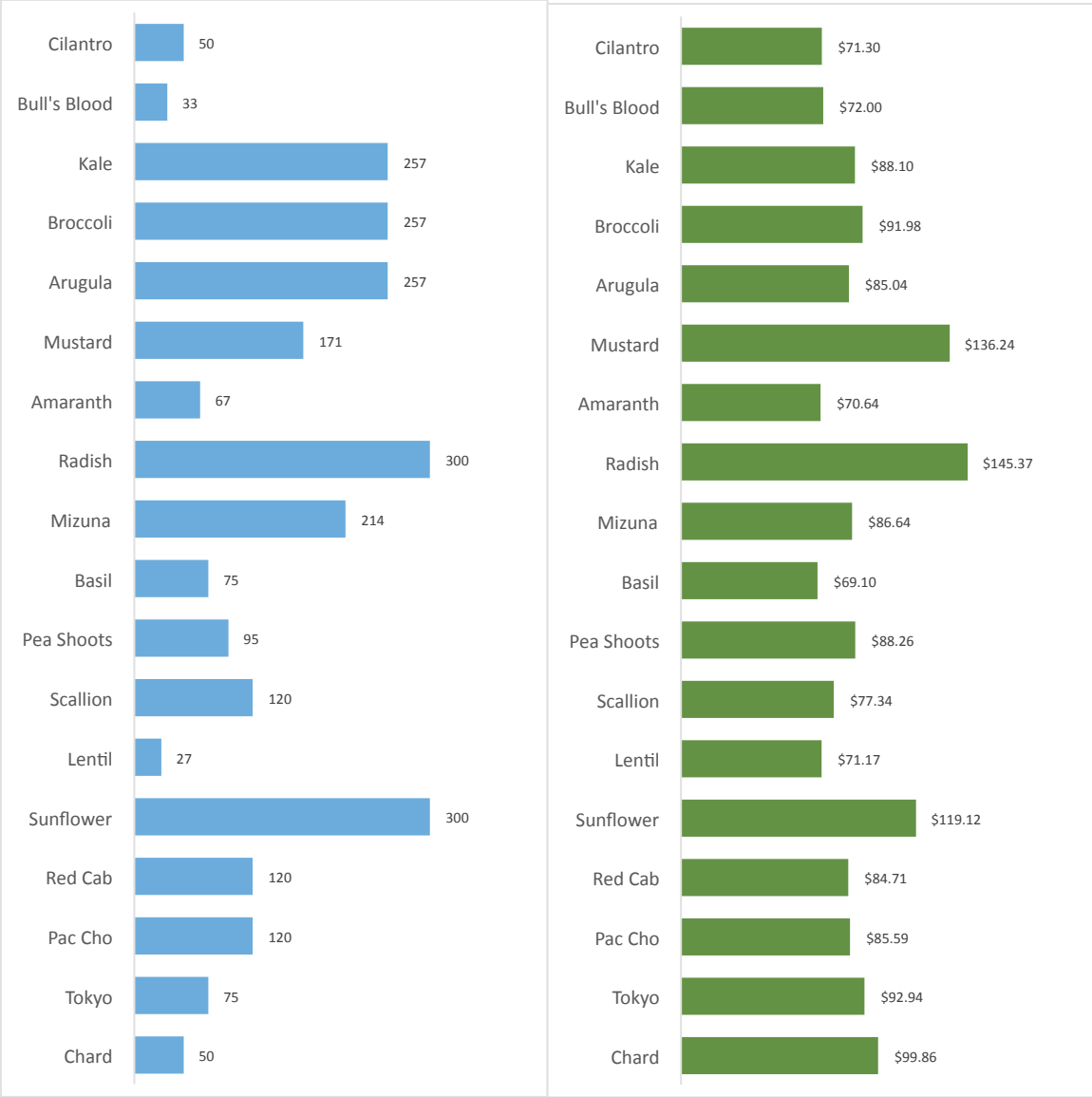
The products with higher absolute margins will be the ones with the highest costs. Nonetheless, most of the high costs are associated with less productivity and with increased time to maturity. These

are both negative correlated with the number of units sold per month as the turnover per tray will be a lot lower – the amount of crop life cycle in each tray in a given period.

Crop varieties with higher costs and high absolute margins, given the low productivity and increased life cycle, fall in the middle range of monthly average total profits, such as Cilantro, Bull's blood, Lentil and Chard. The products presenting the greatest products in the period are those having an optimal mix between cost and production cycle, such as Mustard, Radish and Sunflower. Some with very little costs but with not as high production are affected by the 20% markup pricing methodology and present lower than average aggregated profits such as Amaranth, Basil and Scallion.

When the pricing strategy is changed, profits per product are directly affected. A price range of over 1,000% of microgreens (\$1.61 of Arugula vs. \$13.05 of Lentil) may not be practical from a commercial standpoint. Depending on the new strategy, the lower costs products could benefit from higher prices while the more expensive could be negatively affected. In fact, Black Pearl Gardens charges a fixed price for all of its products, as discussed in the next chapter.

When analyzing the aggregated financial figures we conclude the business, as set in this scenario is very profitable. With the markup price strategy all products sold are profitable and therefore aggregated profits are positive. Based on the scenario being discussed, we estimate \$ 1,635.50 of profits per month, after paying for all direct costs, including labor. Given the almost \$ 50K initial investment in setting up activities, the payback period becomes 29 months. Since it's expected that these investments will last for substantially more than the payback period, investors can derive great returns from the capital injected. The internal rate of return (IRR) - on real terms - is around 30% when empirically assuming that the project will last for 5 years. Additionally, when empirically considering a 10% discount rate the Net Present Value calculated is \$24,332.44 proving the feasibility of the scenario analyzed.



**Figure 8 and 9** Monthly Average Number of Packages Sold and Total Monthly Profit per Product

**Table 6** Aggregated Financial Figures and Return on Capital

Description	Value
TOTAL Revenues	\$8,177.03
TOTAL Cost	\$6,541.62
TOTAL Operating Profit Per Month	\$1,635.41
TOTAL Investment Cost	\$47,628.00
Payback [# of Months]	29.12
IRR – 5 years	30%
NPV – 10% discount rate	\$ 24,332.44

Source: Group Analyses



## 6.6 Considerations about Black Pearl Gardens



**Figure 10 and 11** Illustration about Number of Packages Sold and Profit per Product

Black Pearl Gardens currently charges a fixed price for all of its products, contrary to the 20% markup pricing strategy described in our hypothetical scenario. As previously discussed and illustrated in the following picture, the strategy leads to different profits across the various crop varieties. In a profit maximization scenario, the recommendation would be to produce only those crops presenting higher profits. Nevertheless, the portfolio of varieties Black Pearl Gardens currently produces has a great impact on sales. Customers usually want to choose among different varieties and will choose many of their suppliers based on the diversity of offering. In fact, the fixed price charged by the restaurant

generates a lot more aggregated profits than the 20% markup pricing strategy. Lower cost varieties end up being sold for much more than only 20% markup and makes up for the losses encountered in the higher costs varieties. In addition, the company does not allocate an evenly number of trays to each of the variety.

In reality, Black Pearl Gardens ends up producing a lot more of the most profitable varieties. The aggregated profits are proportionally superior to those presented in our proposed scenario. The return on capital investment is higher and quicker for the company. Unfortunately it is impossible to estimate whether the company is operating at the profit maximization level, given the lack of data about demand. Nevertheless, we can conclude that managers have somewhat done a good job evaluating demand and obtaining higher profits than the 20% markup pricing strategy. Further studies about demand such as market research, customer satisfaction, willingness-to-pay, would have to be made to better assess the full profitability potential of an indoor farming business similar to Black Pearl Gardens.

## **7 Conclusion**

In conclusion, we have several recommendations for someone interested in developing a project similar to the Black Pearl Gardens. Based on trending social media data, it is apparent that 'indoor urban farming' is salient within the US population today, and so we conclude that the social climate in our society is ripe to embrace urban agriculture. In addition, we have found through cost benefit analysis that a project similar to this one can be highly lucrative for the grower, even when taking into account input costs and fair payment of employees. That being said, it is important to consider and prepare for several factors before starting the large undertaking of a functional indoor farming project. The future of Black Pearl Gardens is bright, and our client is looking forward to expansion to her recently purchased 17-acre mixed use farm. While the proposed eco-friendly building is just one example of a feasible structure for the farm, it represents a unique vision to incorporate a restaurant, teaching space, and market space all in one structure.

It is beneficial to ensure that all stakeholders are on the same page with funding and project development, as well as that there are several employees with diverse and complementary skill sets that can effectively shape the vision of the project within budget constraints. In addition, it is difficult to make a general statement on the sustainability of this project in relation to energy input. While the electricity inputs from grow lights is much higher than electrical inputs from similar conventional agricultural processes, water use is much lower. In addition, this project is not using industrial tractors,

tillage, chemical inputs, etc., which should be taken into consideration when considering the overall impact of the space. Its use of otherwise dead space also contributes to its sustainability.

As this report is intended to assist those interested in creating a similar project, we encourage others to evaluate the overall picture of this project when assessing its sustainability, and then make their own accommodations pertinent to their unique growing space and sustainability concerns. The Black Pearl Gardens continues to be a work in progress, with new changes occurring on a weekly basis. Our client aims to continue increasing the project's overall feasibility, while exploring new and exciting endeavors to further the project's reach and profitability.

## **8 Acknowledgements**

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## 10 Appendix

### 10.1 Pictures of Black Pearl Gardens



**Figure 12** Black Pearl Gardens in March 2015



**Figure 13** Black Pearl Gardens in October 2015