Farmers’ Perceptions of an Innovative Food Production Technology: Freight Farms

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Abstract

The Freight Farm company grows leafy greens and basil inside of an adapted shipping container; the produce is then sold to distributors and restaurants. To what extent, we asked, is this urban agriculture initiative attractive to farmers? We conducted 13 in-depth interviews and found that most farmers doubted its economic feasibility, questioned its technologies, and the lack of organic certification. We recommend Freight Farms move toward organic production, diversify crops, and help end users find grants to reduce upfront costs.
Acknowledgements

Thanks to our advisor Professor Robert Hersh. Throughout the year he lent his wisdom and guidance to keep us on track to completing a great project. His input and support, along with a sincere interest have helped us maintain our commitment to this project over the course of this academic year. After receiving many criticisms we were able to take his suggestions and better our project to make it a memorable and beneficial experience.

Robert Hersh
WPI

Thanks to our advisor Professor Jennifer Schuberth. Her constant guidance throughout the term of our project kept us motivated. Her knowledge has helped us within the written report we have compiled as well as in our research and interviews. She continually pushed us to strive for the best and achieve our goals. A constant ray of inspiration, she has helped each one of us learn and grow from the challenges we have seen during this academic year.

Jennifer Schuberth
WPI

Thanks to our sponsor Brad McNamara, the co-founder of Freight Farms. Brad was always available to answer questions and help us follow through with a better project. The tours of the Freight Farm were also very beneficial to give us a hands-on idea of how the Freight Farm works and allowed us to see it in operation. In this we were given extra motivation to produce a quality report.

Brad McNamara
Freight Farms
Executive Summary

Today in Massachusetts there is growing interest in reintegrating urban food production within cities. This interest is being fueled by many factors including making use of underutilized land, reducing food miles, and increasing food security. One food system that may contribute to the growth of urban agriculture is the Freight Farm, an innovative technology which has the ability to produce high volumes of crops within a modified shipping container. The Freight Farm may also help overcome some of the barriers involved in expanding urban agriculture such as land usage, acquisition of resources, and the seasonality of local food production. Our interest was researching the applicability of the Freight Farm to peri-urban farming, those farmers growing adjacent to urban locations, and how the Freight Farm may need to be adapted to serve peri-urban farmers.

In Massachusetts there has been growth in local alternative food systems. This transformation is being fueled by a shift in consumer behaviors centered on eating healthier, spending less, and being environmentally conscious. This expansion of the localized food system can be measured by the growth of farmers markets, food hubs, small farms, and community sponsored agriculture (CSA).

Freight Farms is a small startup company with the primary goal as stated by its founders Jon Friedman (CEO) and Brad McNamara, to make it possible for anyone to efficiently grow food anywhere at any time in any climate. They began researching not only how to reduce the footprint of food, but also how to support a local economy. This led to the development of a hydroponic system inside of an insulated shipping container, called the Freight Farm.
The Freight Farm was designed to efficiently produce vegetables using a small space, no pesticides, little electricity, and a closed loop hydroponic system. The Freight Farm has been designed with vertical growing troughs, high efficiency red and blue LEDs, and an environmental controller.

The closed loop hydroponic system prevents fertilizer run off and uses minimum amounts of water. The vertical growing troughs allow more plant sites in a much smaller area. The LEDs provide the grow lighting needed with minimal electricity and maintenance costs.
The environmental controller maintains the air temperature and humidity as well as the nutrient levels of the hydroponic solution.

The goal of this project was to understand the attitudes of farmers about the Freight Farm concept along a number of criteria—cost, productivity, aesthetics, farming practice—in order to determine if there is a viable market for the Freight Farm. We also sought to identify what technical and operational changes would make the Freight farm more attractive. We setup four objectives to meet these goals. The Freight Farm system was compared to a greenhouse with a similar growing capability and a system operating annually. The opinion of farmers towards the Freight Farm system was gathered and potential issues with the Freight Farm were identified. The issues that were most frequently identified by farmers were researched and potential solutions to these issues were proposed.
The annual Freight Farm operating costs were compared to the costs of a heated greenhouse that was determined to have the equivalent growing potential of the Freight Farm. The Freight Farm has 3000 plant sites, with estimated square feet per plant site the equivalent greenhouse would be 3000 square feet. We then researched greenhouses on the web to determine the costs of greenhouses. The USDA provided a tool that could be fed greenhouse information and provide an estimate for the operating costs associated with the data entered.

Through emailing and calling over one hundred farmers we conducted 13 phone interviews with farmers located throughout Massachusetts and Rhode Island. We started by contacting various agricultural agencies in Massachusetts such as the Massachusetts Farm Service Agency, the Northeast Organic Farming Association (Mass Chapter), the Massachusetts Farm Bureau Federation INC, and the Federation of Mass Farmers Markets. We then began contacting farms listed on Farmfresh.org starting with the farms closest to Worcester and then moving outward. In order to find an appropriate group of farmers to interview, we chose to contact those that grew vegetables or herbs. However, we did record information about the farms we had interviews with. Some of the information we recorded included size of the farm, the distribution channels used, the use of greenhouses/hoophouses, and the number of laborers. Through our interviews we gathered the farmers’ opinions on the Freight Farm and the various components of the Freight Farm system.

When all the individual team members had conducted their interviews the team compiled the information that was gathered. The information was examined and common themes from interviews were extracted. These themes provided the basis for further research into how the Freight Farm could be modified to better serve the peri-urban and urban farmers. Hydroponic organics and government grants that may apply to the Freight farm were both researched further.

Our interviews and research led us to a number of findings around farmers’ perceptions of the Freight Farm concept and how it can be adapted to be a more attractive option for urban and peri-urban farmers. The first finding from research was that the Freight farm is a competitive option for growing year round when compared to heated greenhouses. Our
interviews with farmers provided us with opinions on the Freight Farm and insight into how the Freight Farm is perceived by the farming community. These interview findings can be grouped into three major themes, the economic viability, technological concerns and farming philosophy. Based on the interview findings further research was conducted resulting in additional findings on organic hydroponics and government grants.

Through interviewing farmers and researching we developed a number of recommendations. The first three of our recommendations will help reduce the concerns around economic viability of the Freight Farm by increasing the revenue or decreasing the costs associated with a Freight Farm. Our four recommendations are listed below.

- First, we recommend increasing the crop variety available in each Freight Farm and to develop other Freight Farms for new crops. This will alleviate some of the farmers’ concerns around the economic viability of the Freight Farm by providing units that produce higher premium crops.
- Second, we recommend providing potential clients with information on the grants available. Providing a service to the farmers that helps reduce either operational costs or purchase cost of the Freight Farm may be beneficial to both farmers and Freight Farms.
- Converting the Freight Farm to an organic hydroponic system will attract farmers that are interested in providing certified organic produce. Many of the farmers suggested that they would be more interested if it could be organic. This modification may increase the operating costs of the Freight Farm but organic produce is sold for a higher premium. This should increase the profit margin of the Freight Farm increasing the economic viability of the Freight Farm.
- Finally, we recommend changing the Freight Farm marketing material because many of the farmers concerns were due to skepticism caused by lack of information in the materials. The marketing material should provide more details on expenses and production capabilities. The materials should not just state these numbers but explain how the numbers were produced.
Authorship

Shawn Czerniak was the primary author of the recommendations chapter. He was also responsible for researching grants that may be applied to the Freight Farm. He wrote the interview protocol as well. He contributed to the creation of the final presentation and the initial draft of the findings chapter.

Corey Majeika was the primary author of the abstract, introduction, and methods chapters. He also researched greenhouses and gathered information used for cost comparisons. He worked with ensuring the references within the paper were accurately cited.

Ray Stockwell was the primary author of the findings chapter and the executive summary. He also made significant contributions to the draft of the methods chapter. He researched hydroponics and organics, determining if organic hydroponic systems exist. He also acted as the main contact with the team’s sponsor throughout the year.

The Background chapter was a group effort and each group member contributed to this section. Each member also contributed to the interviews that were conducted between January and March.
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1.0 Introduction

Over the past two decades, food insecurity has risen in the United States. Food insecurity can be defined as a lack of easily obtained healthy food. As the chart below depicts between 1995 and 2011 food insecurity has risen from 12% to 15% of households, while very low food security, increased from 4% to nearly 6% of households. Very low food security can be defined as “reports of multiple indications of disrupted eating patterns and reduced food intake,” previously labeled as food insecurity with hunger (Definitions of Food Security, 2012).

![Trends in prevalence rates of food insecurity and very low food security in U.S. households, 1995-2011](image)

Prevalence rates for 1996 and 1997 were adjusted for the estimated effects of differences in data collection screening protocols used in those years.


Along with this, the prices of healthier foods within the United States have been on the rise for decades as seen in Figure 7. In response to a desire for low-priced health food, as a way of improving food security, there has been an increase in the activity of urban agricultural practices near areas with high density populations (McClintock, 2010). According to the Environmental Protection Agency (EPA), urban agriculture has the ability to “improve access to healthy, locally grown food” which could solve some of the problems with food insecurity.
Sources have shown that in Massachusetts, there has been a rise in the number of small farms, farmers markets, community sponsored agricultures, and food hubs. The localization of food production is occurring as the public desire fresh, locally grown foods in increasing numbers, and makes use of the related resources available to them.

Figure 7: Changing Food Prices in the U.S. Adapted from (Leonhardt, 2009)

Within an urban environment, it has been seen that urban agricultural practices may have difficulty in obtaining access to land (Alexander, 2004), water (Niemczynowicz, 1999), and startup capital (Community & Economic Development Committee of Milwaukee, 2011), in addition to the seasonality of weather in certain areas. According to the United States Census Bureau, the percentage of crop land across the U.S. has been decreasing since 1982 while developed land has been on the rise (U.S. Census Bureau, Statistical Abstract of the United States, 2012). Much of the land in cities is being used, and the available land may suffer from
being mothballed (Alexander, 2004), containing contaminated soils (Brownfields Frequently Asked Questions, 2013), or delegated to a different purpose.

In response to the various barriers that hamper current urban agriculture techniques, a new company called Freight Farms has emerged in the field of food production. The two co-founders of the company want to introduce a new system for growing food that is more efficient than current methods and automated in order to promote sustainable agriculture. The Freight Farm concept centers around the production of food inside of a sealed container, with an overall emphasis on making efficient usage of the small physical space that the container occupies. It can be used on plots of land which are abandoned or contaminated and that could not be used for traditional farming. Recently, the Freight Farm has been marketed for small scale use inside cities, showing its potential to expand the urban food production that is currently taking place. The system does not rely on large plots of open land and soil, or a high consumption of water for growth, and so it is not susceptible to the barriers hampering traditional farming practices inside cities. In addition, the Freight Farm has the ability to contribute to current urban agriculture practices by providing healthy and affordable food while also promoting the rise of entrepreneurs looking to address the inefficiencies within our food system.

The Freight Farm concept has been targeted for city use, particularly at locations such as parking lots or underutilized parcels that cannot be used for traditional farming. However, farmers who operate farms on the periphery of cities, and close to markets, may be able to utilize the system in order to supplement their own food production in a multitude of ways. The container could assist individual farms by helping them expand their markets, develop new revenue streams, or extend their growing season. Farmers who are growing specific foods on their land could use the Freight Farm in order to be able to have an additional crop supplementing their standard harvest, either for personal use or as a secondary revenue stream. For farmers who are interested in being able to extend their growing season and possibly sell food year-round, the system offers an alternative to the current options, such as greenhouses.
The project’s goal was to understand farmer’s perceptions in regards to the system, and investigate what changes could be made to the system that would increase its usefulness in the eyes of growers. To achieve this goal, we contacted 113 farmers via email and phone calls, and conducted in-depth interviews with thirteen farmers in the state of Massachusetts, who were primarily growing herbs and vegetables. The farms ranged in size from 2.5 to 140 acres, with a large range of growing experience, and about half of the farms using greenhouses or hoophouses. We found that the farmers were concerned about the technologies being used in the system, the high initial price point, and the inability for organic certification. Our hope is that our analysis will lead to operational changes in the Freight Farm that will ultimately make it more attractive and economically feasible to more growers.
2.0 Background

This chapter provides the background information needed in understanding the concept of urban agriculture, its growth in Massachusetts, Freight Farm’s role in urban food production compared to competing techniques and a technical explanation of what a Freight Farm consists of. The chapter begins with a discussion of a few of the driving factors for the urban agriculture movement and introduces the benefits that it can provide to communities. Next, we review barriers limiting urban agriculture focusing on Massachusetts. We then consider how the Freight Farm emerged to promote urban food production and examine the technical aspects of the Freight Farm.

2.1 Trends in Urban Agriculture

This section first defines urban agriculture and then discusses the factors driving it. Urban agriculture is not a new concept. Reviewing the history of New England’s cities shows that farming and city life went hand in hand until the industrial revolution of the 19th century. The industrial revolution changed the relationship between cities and agriculture, with the ability to produce food on a large scale and to transport food into cities. As cities and populations grew, the farms were pushed further outside of the urban environment, with officials not recognizing a need for food production within the city (Hodgson, Campbell, & Bailkey, 2011).

Urban agriculture can be defined in many ways; a basic explanation would be the growing of crops or raising of animals within a city for local consumers. For simplicity, a standard description that could be used is from the Community Food Security Coalition (CFSC), specifically the Urban Agriculture Committee. They define it as: “Urban Agriculture is the growing, processing, and distributing of food and other products through intensive plant cultivation and animal husbandry in and around cities.” (Nasr & Bailkey, Fall 1999/Winter 2000, p. 6)

There are many driving factors for urban agriculture ranging from economic to environmental protection and public health. The economic driving factors for urban food growth are mainly focused on reclaiming vacant land within cities and developing the local economies. Using vacant city land for urban agriculture can reduce land maintenance costs,
stimulate the local economy, and increase property values (Hodgson, Campbell, & Bailkey, 2011). Also, the proximity of the food within urban areas can lead to lower prices because transportation costs would be lower. The reduced price of food allows households to spend money on other expenses.

The environmental benefits of urban agriculture include reduced food miles, reduced storm water runoff, and decreased air pollution. According to Van Passel (2013) food miles can result in environmental effects such as air, soil, and noise pollution. The concept of food miles is that transportation of food results in harm to the environment and increased food costs through spoilage (Van Passel, 2013). The greater the distance food travels, the greater the costs of transportation, due to fossil fuel cost and food spoilage. The environmental impact of food miles is reduced carbon emissions from reduced transportation.

Urban agriculture has also been seen as a means to help local income communities gain access to healthy and nutritious food. There has been extensive research into food deserts, a geographical area that may have insufficient quantity or quality of food or systematically higher food prices (Besharov, Bitler, & Haider, 2011), and food security in low income city neighborhoods. Agencies such as the Center for Disease Control (CDC) and the USDA have both published information and statistical data about the growth of food deserts. It can be seen in Figure 8 that food deserts are abundant throughout the United States. Each area which is highlighted is attributed with having a food desert. Urban agriculture could have a great impact on the reduction of food deserts because, according to the USDA, 82 percent of those affected by food deserts live in urban areas (USDA Office of Communications, 2011). The concern is food deserts have an insufficient quantity of food, are lacking healthy food choices, or have higher food prices (Besharov, Bitler, & Haider, 2011). The reduced availability of healthy food and higher prices leads to low income residents purchasing high sodium/high fat foods that can be preserved. Through increasing the amount of fresh vegetables available in these areas health risks such as diabetes and heart disease may be reduced.
Urban agriculture is constrained by city zoning as well as environmental and health risks. Currently there is a need for city planners and zoning commissions to bring agriculture back into cities. “By the mid-20th century, many cities’ zoning codes no longer included farming as a recognized land use; residential development had claimed most former farmland inside cities, and modernist planners did not see agriculture as part of city life.” (Rogers, 2011, p. 1) The environmental and health risks of urban agriculture involve pollution from fertilizers and pesticides. According to an article that appeared in Agronomy for Sustainable Development, the most significant constraint to developing urban agriculture is the use of pesticides (De Bon, Parrot, & Moustier, 2010).

2.2 Urban Agricultural Growth in Massachusetts

The food system in Massachusetts is transforming. This transformation is being fueled by a shift in consumer behaviors centered on eating healthier, spending less, and being environmentally conscious (McClintock, 2010). A major part of urban agriculture is creating alternative food networks. According to (Jarosz, 2008, p. 232)

Rural restructuring in metropolitan settings entails, among other things, the rise of small-scale farms dedicated to supplying nearby cities and towns with seasonal foods sold in venues such as farmers markets and community supported agriculture (CSA).
This implies that the expansion of the localized food system can be measured by the growth of small farms, farmers markets, food hubs, and community sponsored agriculture (CSA).

The rise of small farms in Massachusetts provides evidence of the growing localized food system in Massachusetts. According to the USDA agricultural census of 2007 (USDA Agricultural Census, 2007), the average farm size has decreased by 21% over the last decade which is a decrease in average acreage from 85 acres to 67. Counteracting that, the number of farms in Massachusetts grew from 6,075 in 2002 to 7,691 in 2007. While the average size of farms in the state has decreased the number of farms has increased showing evidence of the growing trend of the localized food system.

Farmers markets are an additional source of the rise in urban agriculture. According to Michigan State University,

Farmers markets are becoming an important part of the food industry, and the environmental benefits that go along with it – reduced transportation costs and reduced vehicle emissions – are creating a driving force for the increasing popularity of these markets (Stuever, 2012, p. 1)

These farmers markets are also a great way to help small scale farmers while providing more “stability for local economies” (Stuever, 2012). The following statistics shows the number of farmers markets in Massachusetts has increased over the past decade, further indicating a growing localized food system. According to the USDA, there was an increase from 2011 to 2012 of 9.6% (Farmers Market Search, 2013). Also, the data shows that there are 271 farmers markets operating within Massachusetts. Of these 271 markets, only 59 of them are set up to run during the winter, indicating that one of the issues with the local food system in New England is growing and distributing food throughout the entire year. Finding methods for farmers to extend their growing seasons and adjust their distribution channels will be necessary to alleviate this problem.
Another indicator of the localization of the food system is the rise in food hubs. The USDA’s working definition of a food hub is “a centrally located facility with a business management structure facilitating the aggregation, storage, processing, distribution and/or marketing of locally/regionally produced food products.” (Regional Food Hubs: Linking producers to new markets, Unspecified) Food hubs help foster urban agriculture by providing storage, processing and distribution. According to Merrigan (2011) food hubs address the challenges faced by small and midsized producers to gain access to infrastructure. Infrastructure such as trucks, warehouses, processing space and storage are needed to reliably meet market demand, especially from larger institutional buyers in their region. Many cities across the country have begun incorporating food hubs into their regional food chain, for example Massachusetts currently has 14 food hubs throughout the state (Working List of Food Hubs, 2013).

According to the USDA, in basic terms, CSA consists of a community of individuals who pledge support to a farm operation so that the farmland becomes, either legally or spiritually, the community’s farm,
The concept of Community-Supported Agriculture has been around for decades in the United States. Massachusetts and New Hampshire were the first two states to have a farm which was involved in the CSA movement (Adam, 2006). According to the USDA there were 60 CSAs in Massachusetts in 2006. Data from the Robyn Van En Center at Wilson College says that there are currently 77 CSAs throughout Massachusetts. This shows an additional area of growth within urban agriculture in Massachusetts.

Not just restricted to the United States, the movement towards urban agriculture has been up and coming throughout the world. “As more frequent and more damaging disasters confront a population that is moving to the world’s cities, urban farming often offered a critical solution.” (Smit, Nasr, & Ratta, 1996) Urban agriculture is a system which is usually more beneficial for lower-income groups, as food security and availability are greatly increased within a healthy urban agriculture setting. In one example, Hartford, CT uses “farmers’ markets, a Community-Supported Agriculture (CSA) project, community gardens, youth gardens, solar greenhouses, and a direct farmer-to-school marketing program to put the urban consumer back into the food picture.” (Elizabeth Boon Wheeler, 1995) The table below shows population trends for the largest cities in New England. Based on 2005 estimates and the 2010 census (USDA Agricultural Census, 2010), it can be seen that New England cities have been experiencing population growth in recent years. There has also been growth in suburbs surrounding the major cities in the Northeast, as seen in Figure 10. The establishment of urban agriculture in these major cities is becoming more and more necessary as the population increases and more people move into urban settings.
Table 1: Population increase in select New England Cities from 2005-2010

<table>
<thead>
<tr>
<th>City</th>
<th>2010</th>
<th>2005</th>
<th>% increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boston, MA</td>
<td>617,594</td>
<td>559,034</td>
<td>10.48</td>
</tr>
<tr>
<td>Worcester, MA</td>
<td>181,045</td>
<td>175,898</td>
<td>2.93</td>
</tr>
<tr>
<td>Providence, RI</td>
<td>178,042</td>
<td>176,862</td>
<td>0.67</td>
</tr>
<tr>
<td>Springfield, MA</td>
<td>153,060</td>
<td>151,732</td>
<td>0.88</td>
</tr>
<tr>
<td>Bridgeport, CT</td>
<td>144,229</td>
<td>139,003</td>
<td>3.76</td>
</tr>
<tr>
<td>New Haven, CT</td>
<td>129,779</td>
<td>124,791</td>
<td>4.00</td>
</tr>
<tr>
<td>Hartford, CT</td>
<td>124,775</td>
<td>124,397</td>
<td>0.30</td>
</tr>
<tr>
<td>Stamford, CT</td>
<td>122,643</td>
<td>120,045</td>
<td>2.16</td>
</tr>
<tr>
<td>Waterbury, CT</td>
<td>110,366</td>
<td>107,902</td>
<td>2.28</td>
</tr>
</tbody>
</table>

Data from: http://www.census.gov/

Figure 4A. Share of Population in Suburbs, Large Metro Areas by Region, 1990-2010

Figure 10: U.S. Suburb Population Growth by Region Adapted from (Frey, 2012)

2.3 Barriers to Expanding Urban Agriculture

Farmers markets, community gardens, food hubs and CSAs can increase access to fresh, healthy food inside of cities, but they face a number of challenges: land access and usage, acquisition of proper resources, and the seasonality of the weather conditions.

Land access and land tenure

For many planners, developers and others involved in urban development, urban agriculture is not typically seen as the best and highest use of land within densely populated
Although cities cover vast areas of land, much of the acreage is used for roads, infrastructure, factories, commercial space, parks and housing. Unfortunately, obtaining and developing land that is unused may be difficult if the properties were abandoned or tax-delinquent, or if there is inefficient tax foreclosure and ineffective nuisance abatement codes, which can confuse who is in control of unused properties (Alexander, 2004). This can be alleviated through land banks that can allow for simpler acquisition and development of the land. Land banks do not exist in several cities across the nation, but there are several large cities that have organized land banks, such as Genesee County (MI), St. Louis (MO), and Indianapolis (IN) (de Wit, 2008). However, the U.S. Department of Housing and Urban development describes the banks as “the conversion of vacant, abandoned properties into productive use,” (Land Banks, 2010) so the urban agricultural proponents must still compete with other community groups or developers for access to these locations.

In previous decades, government programs provided families with access to land owned by speculators allowing them to use it to grow food for themselves during depressions. For example, in 1893 a total of 430 acres of speculator land was provided to 900 families by the municipal officials in the city of Detroit, which then assisted with cultivation of the land (Hersh, 2010). Similar situations may arise today, where properties are opened up by the owners for use by urban agriculture programs to increase the amount of food that is available to the city residents (Food and Agriculture Organization of the United Nations, 2009). The downside to this is that the land does not belong to the farmers; they are working on land owned by another party. The agreement that allows the reserved land to be worked may also require the farmers to leave the land if the speculator just asks it of them, depending on the terms that were set when the land use was being designated (Hersh, 2010). While the time spent working land and producing fresh, local food inside of a city would certainly be meaningful, the limited nature of these conditions would not help advance a sustainable urban agriculture.

Finally, restricting all of the above is the ever present possibility that a large portion of land in the cities could be unusable for agricultural purposes, as a direct result of contaminated soils (Brownfields and Urban Agriculture: Interim Guidelines for Safe Gardening Practices, 2011). Heavy metals and other contaminants are often found in city soils resulting from past
industrial uses. The U.S. Government Accountability Office estimates that there are approximately 425,000 brownfields in the U.S., with further estimates suggesting a total coverage of 5 million acres of abandoned industrial sites (Brownfields Frequently Asked Questions, 2013).

**Startup costs**

Once an organization has obtained land for agricultural usage, funding may be needed to complete start-up operations before production can begin. For example, projects that wish to build structures such as greenhouses, or need additional labor to prepare the land for growth may need to seek the help of investors. The business can apply for a loan from the local government, but will likely need to also seek the assistance of private investors if they wish to fund larger operations. The company Sweet Water Organics sought to construct an urban fish and vegetable farm through the transformation of an abandoned industrial building in Milwaukee, Wisconsin. The company was able to meet its goal and has been in operation for a couple years now, but to do so they first raised over one million dollars between private and government loans, as well as committing personal finances on top of that (Community & Economic Development Committee of Milwaukee, 2011). Once funding is secured, it will be necessary to repay the committed loans through a profitable operation. Depending on how well the farm does, additional support may be necessary if the foods grown are not producing enough to cover the annual labor and energy input costs being used.

After proper funding is secured, the next challenge to overcome is to ensure a reliable and regular source of water for the plant growth. Crops require a continual water supply, as do many other things in cities (Niemczynowicz, 1999), (Moe & Rheingans, 2006). With national water usage for irrigation tripling the public supply usage (United States Water Usage, 2009), it can be seen that agriculture generally has a higher water consumption than the national populace. In addition, it has been shown that general water usage in cities can be much more valuable compared to the relative benefits of an equal amount of water being used for traditional crop irrigation (Howe, Lazo, & Weber, 1990).

*Seasonality of the local food production*
In the northeastern climate, the weather patterns are often unreliable, and can result in such conditions as snowfall as early as October, and as late as March. If the crops are being grown in standard fields without additional cover and heating, then their production will be more affected by the weather than crops that have received some cover. Simple single layers of polyethylene or similar plastics over a frame covering the crops can alleviate the weather conditions, but would not be able to sustain growth during the colder months due to an inability to provide necessary amounts of insulation. In order to allow growth to continue during more hostile weather conditions, the growers can construct greenhouses or less expensive high tunnels to protect the crops and extend the growing season. The downside to this is the additional investment needed for the construction of proper greenhouses, as well as the continual costs associated with maintaining them.

2.4 The Emergence of the Freight Farm
Freight Farms is a small company based out of Boston, Massachusetts that is hoping to offer a new method of farming in an effort to promote sustainable agriculture. The company is working to sell freight shipping containers that have been modified to contain a hydroponically
based growing operation. The primary goal of Freight Farms, as stated by its founders Jon Friedman (CEO) and Brad McNamara, is to make it possible for anyone to efficiently grow food anywhere at any time in any climate. They began researching not only how to reduce the footprint of food, but also how to support a local economy.

Friedman and McNamara were able to get started with an initial investment of $30,975 through kickstart.com, which they used to build a prototype of their farming concept. The prototype is currently owned and operated by Freight Farms and generates revenue through growing and selling produce year-round. The prototype is located at Clark University and the produce is distributed by Sodexo Food Service. Currently, Freight Farms produces units for their customers, which include wholesale distributors, restaurants, grocery stores, schools, and hospitals. Freight Farms participated in the “MassChallenge Accelerator” class of 2012, which is a program to help fund local start-up companies centered on social impact. Freight Farms was successful at generating interest in their product through the challenge, and is now working to fill orders and improve their unit.

The initial farm design is geared towards growing leafy greens and herbs such as lettuce and basil, but Freight Farms is working on new farms designs that will be able to grow vine-plants and mushrooms. The farm unit is built out of a modular shipping container, meaning that it is a regular shipping container that has been modified to be insulated. The Freight Farm is fitted with a ventilation and air-conditioning system as well as a heating system to allow for
growth in all climates. The farm currently has about 3000 plant sites, which is approximately equal to one acre of land, for leafy greens and herbs which grow using a nutrient distribution and circulation system and LED lights. Currently, Freight Farms sells units for about $60,000 to distributors and other customers.

2.5 Technologies of the Freight Farm

The Freight Farm is hoping to offer itself as a newer and hopefully more efficient method for promoting sustainable agriculture. There are many important aspects of the system discussed, which includes some more advanced technologies used throughout the operation. These technological aspects are what set the Freight Farm apart from other farming methods. The system’s key technologies that contribute to its image include its usage of hydroponic growth, a climate control device in the insulated environment, an LED lighting system, and an overall implementation of a high degree of automation.

Hydroponics

As the Freight Farm is aiming to maximize the volume efficiency of the space used for growing, it must try and compact the system in every way possible. One way in which it achieves this is through the usage of hydroponics to supply the plants with the water and nutrients that they require as opposed to a more open and spread out irrigation system that is
more common on farms. Though this is a different method of growth, research has shown that the two irrigation systems do not result in significantly different products in regards to lettuce (Domingues, 2012), one of the main advertised crops for the Freight Farm. The hydroponics are administered via a vertical drip irrigation described as being a modified vertical nutrient film technique. The system administers a set amount of pH controlled water each hour that is enriched with a specific set of nutrients for the plant’s growth, and that is constantly monitored. The system also monitors the water’s conductivity and temperature, and controls the implemented level sensors and flow switches.

![Inside view of the Freight Farm showing growing chambers, lighting, seedlings, and processing table](image)

**Figure 14:** Inside view of the Freight Farm showing growing chambers, lighting, seedlings, and processing table

*Climate Controlled*

As the system aims to be used for extended growing season through the entire year, a certain amount of climate control is needed to ensure that the environment inside the farm is appropriate for plant growth. The primary ways the system achieves this is through the usage of specific freight containers that are pre-insulated, and a heating and cooling unit for environment control. The unit that is installed is capable of controlling the humidity and the temperature, with a separate device for controlling the CO\textsuperscript{2} levels. This system ensures that the conditions in the box are constantly adjusted and altered to ensure that healthy plant growth is occurring.
**LED Lighting**

As the growing operation is completely contained inside of a sealed freight container, an alternative source of lighting is needed to supply the plants with sufficient energy for growth. The Freight Farm achieves this by using several rows and columns of LED lights that are aimed towards the plants in such a way that the plants will still be growing towards the light sources. The lighting fixtures are retractable, allowing for increase options for movement in the farm while harvesting the matured produce.

![Figure 15: Wireless tablet for settings control](image1)

**Supporting Research**

As the LED lighting systems is vastly different from the natural lighting provided by the sun, it is helpful to highlight research that has been done to support the types of lighting systems that the Freight Farm employs. Supplying the energy that is necessary for plant growth though lighting is costly and the Freight Farm aims to alleviate this though their implementation of the LED lighting. It has been shown that LED lights are highly efficient compared to standard lighting, and that they are suitable for usage in plant growth (Yeh, Naichia, & Chung, 2009). In addition to this, the Freight Farm is utilizing a certain combination of LEDs that has been proven...
to be more effective at promoting plant growth compared simpler LED lighting setups (Yorio, 2001), as well as producing low amounts of excess heat.

**Automation**

Perhaps the largest part of the implemented technologies is the degree of automation that is being built into the Freight Farm. The high amount of automation assists in regulation of plant growth and control throughout the whole system, and is controlled by a central tablet that is used by the farmer to regulate the system. In regards to the climate, the implemented sensors spaced throughout the container measure the CO2 levels, the humidity, and the ambient temperature in the enclosure, and send this information to the central controller. Based upon the settings that are desired by the farmer, the controller will then send signals to the climate controlling device to adjust the systems ambient environment. This type of regulation is also used to measure the nutrient content and pH balance of the water that is recycled after passing by the plants, and it will then add nutrient solution and increase or decrease the pH levels to adjust them for the optimal values before the water is cycled through the system again. Settings for the schedule of lighting throughout the day are also adjustable from the control tablet, as well as the ventilation and airflow system, and high and low levels for variables that are being monitored, with an alarm that is triggered when those values are breached. Overall, the system is designed with a high degree of technologies and automation to assist in the farm’s usage.

**Overcoming Urban Agriculture Barriers**

As discussed previously, there are several different factors that prevent urban agricultural practices from proliferating quickly throughout cities. Due to the contained and efficient nature of the Freight Farm, it is able to operate in areas that traditional urban farming might be unable to. As the Freight Farm is a contained system designed to maximize the space available, the concern over land used is less significant: several farms could be placed on a single lot for a high volume of production. If the land that the Farm uses is not permanent, it would be simpler to move the container than for farmers to lose the improved soil that they have spent years developing and cultivating. The Freight Farm is also not limited by the existence of brownfields, as it does not rely on the soil for crop growth and health.
In regards to the water usage issues, the hydroponics component of the farming is designed to use an overall small volume of water, and recycles and reuses the water that it does provide to the plants. There is an initial cost associated with the purchase of the Freight Farm, but once a unit is purchased it would be constructed and delivered ready to produce crops. The yearly costs of operating the system have also been projected as less than the costs of greenhouses as was discussed in the previous sections. Finally, the enclosure that contained all of the crops is well protected from the weather by a rigid metal exterior and additional insulation along the inside of the container. All together, the Freight Farm system projects itself as being able to provide a reliable platform for urban agriculture that is less prone to common barriers.

While the Freight Farm system seems to be an important technology to promote urban agriculture, could it also be of use to growers located close to cities? While marketed towards businesses and distributors, would individual farmers have an interest in such a system, as means of supplementing their growing season and revenue stream? Answers to such questions may help the Freight Farm develop new market niches and help bolster the viability of small to mid-scale farming operations.
### 3.0 Methods

The goal of this project was to understand the attitudes of farmers about the Freight Farm concept along a number of criteria—cost, productivity, aesthetics, farming practice—in order to determine if there is a viable market for the Freight Farm. We also sought to identify what technical and operational changes would make the Freight farm more attractive. To accomplish this, we developed the following objectives:

1. Evaluating and comparing systems to understand what differences exist between the Freight Farm and greenhouses, specifically looking at initial and annual costs of operation for year round growth.
2. Better understand the perspectives of local farmers about the utility of the Freight Farm in their operations.
3. Identify the type of changes farmers would like to see in the Freight Farm to make it a more attractive and viable option.
4. Develop recommendations for the sponsor with regard to marketing the Freight Farms as well as feasible upgrades that could benefit the system and potential end users.

#### 3.1 Evaluating and Comparing Systems

The Freight Farm was evaluated and baseline information was collected to determine how it compared to other technologies, such as greenhouses and hoop houses, used for extending the growing season. Such criteria included the purchase price, resource costs of the freight farm, such as water usage, electricity usage, costs of nutrient solutions, labor required for operation, crop turn around, and total crop output. We researched similar criteria and resource usage of greenhouses to understand exactly how well the Freight Farms system compares to the other options on the market that are available to the farmers. We worked with our sponsor to obtain accurate information on the costs associated with a Freight Farm, as well as an understanding of what specific differences are existent in a Freight Farm compared to the other options. For greenhouses, we focused on the monetary costs of operation and obtained data for this by looking online and finding cost reports by individuals who had built a greenhouse, as well as a detailed guide on greenhouse construction with associated material.
and labor costs. The annual cost involved with running a greenhouse was estimated using detailed online USDA calculators, with further detail listed in Appendix G.

3.2 Better Understanding the Perspectives of Local Farmers

The first task in determining if there is a market for the Freight Farms product was to identify the target population. We selected farmers operating in the greater Massachusetts area based on available growing season, population density and location. The available growing season was important in identifying the target population. If there wasn’t a need for extending the growing season there would be considerably less interest in the Freight Farm. The population density was considered when identifying the target area because we reasoned that there would be more interest in areas with a higher population density. Areas with a higher population density would be less likely to have large food production areas, and so they could make use of the system’s potential for application to urban environments. Finally, location was considered and Massachusetts was considered the best location for our research due to our sponsor working out of Worcester and Boston.

To find farmers in Massachusetts to interview, we spoke with local associations that are in contact with growers. Groups we contacted include the Massachusetts Farm Service Agency, the Northeast Organic Farming Association (Mass Chapter), the Massachusetts Farm Bureau Federation INC, and the Federation of Mass Farmers Markets. Farmers were also to be contacted directly through email and cold calls. Of the potential Farmers to be contacted, an emphasis was placed on farmers that were growing vegetables, and herbs, as these were the two primary products of the Freight Farm.

To gauge interest in the concept of the Freight Farm, and to learn about the individual farmers growing practices, we developed a semi-structured interview protocol, which can be found in Appendix A. Some key questions we asked in the interview included:

- What size farm do you have?
- How do you currently distribute the goods you grow? (CSA, restaurant, food stand, etc.)
- Do you have any set up for year round growing?
o If yes: What do you have? How efficient is it? Is it more difficult than your regular season growing techniques?

o If no: Do you have any interest in year round growing?

• Based on the cost of the Freight Farm, would you consider purchasing one if it were available?

o Would the aid of government grants make it easier for you to consider buying one of these?

During the course of the project, we contacted a total of 113 farmers through a combination of emails and phone calls, and received a total of 18 responses. Five farmers did not wish to be interviewed, and 13 farmers were willing to talk with us over the phone. The farms contacted ranged in size from 2.5 to 200 acres, some were relatively new family worked farms while other were large businesses that had been in farming for many years. Of the farmers contacted, most produced vegetables and herbs, with specific crops varying by farm, and distributed their food through means such as CSAs, wholesale, farmers markets, and restaurants.

![Farmers Contacted](image)

**Figure 17 Farmer Responsiveness Chart**

### 3.3 Identify the Types of Changes the Farmers Would Like to See

In order to determine what type of alterations would be desired, we evaluated the responses from the interviews with farmers and farming association representatives. As we conducted interviews the information from each conversation was entered into a spreadsheet
database with a focus on such information as farm size and usage breakdown, current usage of greenhouses or hoophouses, and their opinions on the Freight Farm. The critical information we analyzed was based on the farmers’ replies when we asked them for comments on the system, and their ideas for possible changes. We identified common themes from the interviews, such as comments on crop variety, farming philosophies, and general skepticism, and used them to generate areas for further research.

3.4 Develop Recommendations for the Sponsor

Using the information that we extracted from the interviews, we explored the viability of making changes to the Freight Farm and addressing what many farmers found to be the high up-front costs. We met with our sponsor to determine which potential adaptations would be most appropriate. Our sponsor identified hydroponic organics and finding applicable grants as critical areas for research.

Can hydroponic systems be certified organic?

The theme that our sponsor was most interested in was producing food organically using a hydroponic system. We wanted to know what organic certification consisted of, if hydroponics could be certified organic, and what changes the Freight Farm would need in order to meet the certification requirements. Initially, individual materials that were used in the Freight Farm, such as Rockwool Cubes, were examined in their potential for effecting organic certification. To learn from practitioners, we interviewed a hydroponic grower, Sweet Water Organics, and the United States Agricultural Department (USDA), specifically their Agricultural Marketing Service (AMS). Our aim was to discover if non-standard growing methods could be organic by contacting other individuals with an interest in the topic.

Is there Funding available for local growers to offset the initial cost of a Freight Farm?

In order for the Freight Farm to be effectively marketed to farmers we needed to determine its affordability. The information gathered around the initial costs, supply costs, and energy costs contributed to the investment cost, and the capabilities of the freight farm and the current pricing of produce contributed to the return. After determining the return on
investment without government grants or subsidies, we identified potential funding sources to reduce the initial costs of the technology and increase the return on investment. We researched possible methods that could be used to reduce the initial price point of the Freight Farm, through a search for federal or private grants and loans that could apply to the system. We hoped to discover if there were grants and loans that would be applicable to the Freight Farm as a new system, and if the assistance programs would be accessible by individual farmers. After talking to members of the Massachusetts Department of Agricultural Resources and the Carrot Project, it was confirmed that the Freight Farm would be able to receive funding. Potential resources that were investigated include the USDA’s Sustainable Agriculture Research and Education (SARE) program, the Agricultural Environmental Enhancement Program, the Farm Energy Discount Program, and the Farm Service Agency (FSA). We also investigated the Foundation Directory Online (FDO) database, to further search for otherwise unlisted grants.
4.0 Findings
Our findings are based on 13 telephone interviews we conducted with farmers in Massachusetts and Rhode Island between Jan and March, 2013. The characteristics of these farmers varied significantly from one to another. The farm sizes ranged from 2.5 to 200 acres, with most being full time farmers. The farmers interviewed all grew vegetables and or herbs, however some had fruit trees and others raised animals. All of the farmers sell their produce directly through farmers markets, stands, and community sponsored agriculture shares, four of the farms also sell to distributors. This chapter will discuss the findings from these interviews, grouped along the following themes: economic, technological, and philosophical. This will be followed by a brief discussion of concerns surrounding the aesthetics of the Freight Farm. The discussion will then cover the research findings from the interviews.

Finding #1: Comparative Costs
We compared the initial and operating costs of greenhouses to the Freight Farm for the use of extending the growing season throughout the winter months. The Freight Farm contains approximately 3000 planting sites, so it was compared to a greenhouse of similar production capacity, one that covered 3300 sq. ft. (120 ft by 22 ft), about one square foot per planting site. This accounted for the necessary room that the plants would need to grow, as well as the additional machinery and other pieces of equipment needed to facilitate plant growth and inspection in a contained environment. It was found that a greenhouse was less expensive than a Freight Farm in terms of initial investment costs, but that a Freight Farm would cost less annually to operate at full capacity.

As the Freight Farm hopes to provide a service that is currently met through the usage of greenhouses, a comparison between the two served to illuminate the viability of the Freight Farm in an already established market. As discussed, a Freight Farm costs US $60,000 to purchase, which is a large investment for a farmer who has already invested in traditional growing practices. The average cost of a greenhouse was found to be equal to about $15,000 to $20,000, with conservative estimates ranging about $10,000. In this regards, the greenhouse is a much less costly investment than a Freight Farm.
For the annual costs of operation, values between the two systems differed in the opposite direction. Estimates for a Freight Farm to be operated year round place the costs at about $2,300 for energy, water, nutrients, and grow medium. For a greenhouse, calculations are more complicated. Using the given information in Appendix G, the USDA’s Energy Self-assessment for greenhouse energy costs estimates a cost of $12,243 for a year for a greenhouse of 3,300 square feet. This is much more expensive than a Freight Farm, but is not accurate of all greenhouses. Using the suggestions in the Energy Self-assessment program, costs for a 3,300 sq ft greenhouse could be reduced to $3,525 for a year. This estimate is much closer to the energy costs of a Freight Farm, but is based upon the implementation of several different energy efficient but more costly designs detailed in the same Appendix. The implementation of these practices would raise the upfront cost of the greenhouse. Based upon this information, it can be seen that the initial and continual costs of a Freight Farm are not prohibitively expensive compared to a modern, energy efficient greenhouse.

Further, for current growth in Massachusetts, the last Census of Horticultural Specialties that was taken in 2007 (Census of Horticultural Specialties, 2009) showed that there were only 67 operations in the state that were growing food under protection (e.g., greenhouse or hoophouses), with a minimum value of sales of $10,000. Data from the census suggests that on average, greenhouse growers earned $21,400, suggesting that the greenhouses were able to earn about $10,800 from October to March, as calculated in Appendix E. Projected costs for constructing a greenhouse vary, with a detailed guide on greenhouse construction suggesting that a standard greenhouse framework could cost around $13,000 (Flores, 2006). This projecting unfortunately does not include costs associated with the energy efficiency practices suggested by the NRCS and mentioned previously. Such initial investments and operation costs result in greenhouses being harder to setup and maintain when financed directly by the farmer. Costs may be offset through the use of government grants and assistance, but such programs may not always provide as much assistance as the farmer requests.

Finding #2: Economic Viability

The economic viability of the Freight farm was a major concern of many farmers that were interviewed. The issues raised by interviewees were the high initial cost of the Freight
Farm, the limited product line, and the operating costs. The following sections highlight these problems and discuss why the farmers feel that these are important matters that will need to be addressed.

In addition to the high purchase price of the Freight Farm many farmers were concerned with the profit margins provided by the crops that could be grown in the Freight Farm. The farmers were given a chance to see a Freight Farm brochure, seen in Appendix D, before the interviews were conducted. The brochure didn’t provide details on yields and highlighted the “leafy green machine”, with pictures of the system growing leaf lettuce. The only number that the brochure conveys is 3000 plant sites, with no information on harvest cycles. The brochure did suggest that there were options around crop variety, with seven varieties of leafy greens, six of vines types, and four fungus types, but these other units do not exist yet. However, the lack of details may have amplified the farmers’ apprehension around product variety and profit margins. Other materials provided to us by our sponsor covered the yields, prices, and revenues of the Freight Farm. The produce grown in the Freight Farm does have a significant impact on the payback of the Freight Farm. For example, the real annual yield of Bibb lettuce is 21,472 heads, with an estimated price of $1.50 per head this provides an annual revenue of $32,208. Once the expenses for labor (~$8400), utilities ($2,374), annual supplies ($1,200), maintenance ($500), and insurance ($3,000) are subtracted from the revenue there is an estimated profit of $16,734. The cost of the first year of operation is estimated to be $76,974, which includes the cost of the Freight Farm and one year of expenses. Based on this estimate of $76,974 and the profit number of $16,734, Bibb lettuce provides a payback in 4.6 years. Going through these calculations for sweet basil with a real yield of 13,956 lbs., an estimated price of $9.75 per lb. and the same expenses shows an annual profit of $120,597 providing a payback in .7 years.
Many farmers suggested crop varieties that would provide higher profit margins and would alleviate this problem. Cathy Harragian of “The Bird in the Hand Farm”, an organic farm, orchard, and nursery, suggested that the Freight farm be modified to grow different high yielding or high markup vegetables, stating “possibly turnips, mesclun lettuce, mushrooms” (Harragian, personal communication, January 18, 2013). Many farmers also stated that the Freight farm could be used for growing medical marijuana, which would have a much higher profit margin.

The final problem involving economic viability raised by the farmers was around the operating costs of the Freight Farm. Some farmers brought up the energy cost of the Freight farm, while others questioned how much labor it would take to operate the unit. Some farmers pointed out that the Freight Farm makes no use of natural light, stating that a hydroponic system inside a greenhouse may be more feasible. This showed that marketing materials for the Freight Farm may need to be adjusted to provide the energy cost comparisons between a Freight Farm unit and a greenhouse operating throughout the full year. Still other farmers could not explain their lack of interest just stating that it won’t work. One farmer that had already
heard of the Freight farm and stated, “That people are laughing at this thing, it is only useful for marijuana” (Local farmer, personal communication, 1/17/13).

The interviewees that were interested in the Freight Farm concept were curious, wanting to learn as much as they could about the concept. These farmers asked questions regarding the yields, labor costs, energy costs, and purchase price. After discussing the associated costs and yields multiple farmers that were interested in the concept stated that it seemed economically feasible.

The high purchase price combined with the other economic concerns proved to be the largest cause of contention among the for profit farmers that were interviewed. There were beliefs that the system would ultimately not be profitable and that the crops being grown in the system would not bring in enough money to justify the purchase and use of the system. These beliefs resided with the for profit farmers that had no interest in the Freight Farm. However, even among the farmers that thought the concept was economically viable there were still reservations around the high purchase price of the Freight Farm. Many farmers explained that they do not have the capital to make an investment of this size, with most of their capital generated from one year being spent on supplies for the following year.

Finding #3: Technological Concerns

Many of the farmers that were interviewed expressed doubts regarding the technology of the Freight Farm, with beliefs that certain parts of the system would result in a negative impact on crop growth. These concerns focused on the efficiency and spectrum of the lighting system, and on the use of a hydroponic system. Additionally, some farmers expressed concerns about relative humidity, air flow and the environmental controls being used.

The concerns about the lighting system of the Freight Farm varied, but can be grouped into 2 categories: 1) the impact of artificial light on plant health; and 2) the cost of using artificial light is too high, when sunlight is free. A local farmer unfavorably compared the lighting system to natural sunlight and was unsure if such a different energy source would have an impact on the crops grown and plant health. Another farmer, Ashley Howard, expressed similar thoughts, citing the differences in the spectrum of light that the plants were receiving, and the limited types of light being used inside of the container. These concerns were mostly
alleviated when the red and blue spectrum LEDs used in the system were explained to the farmers. Sunlight is full spectrum white light which is composed of a green, blue, and red element. Green plants reflect most of the green light which is why they appear green, so supplying red and blue spectrum lighting instead of full spectrum is more efficient. Still other farmers were unsure as to whether the lighting system would be efficient, expressing that they would not want to pay for lighting when sun light is free. An LED is highly efficient and they have a long life of 50,000 hours compared to other common bulbs like incandescent or fluorescent. The LEDs are also more efficient than other grow lights like metal hydride or high pressure sodium. The final issue farmers had with the LED system was the maintenance/replacement of the lighting system.

Further parts of the Freight Farm that farmers discussed focused on the hydroponic watering system used to supply the plants with proper nutrients, with specifics including the water supply, contamination in the system, and the fertilizer used. In an interview with Jeffery Howards, who operates a small 6 acre farm with two green houses, he stated that “Hydroponics sounds good on the surface, but for the novice farmer, there needs to be education about advantages and disadvantages of hydroponics” (Howards, personal communications, 1/28/13).

There were concerns with supplying utilities, such as water and electricity, to the Freight Farm. Cathy Harragian expressed that providing utilities to the Freight Farm may be problematic for some farmers, explaining that her farm is land locked and would not be able to provide the necessary utilities (Harragian, personal communication, January 18, 2013). She does not own the adjacent properties and does not have access to utilities. The concern around the fertilizer being used was that it was synthetic which was not natural, a topic which was actually brought up a lot and is discussed in the farming philosophy section below.

Interviews with a few of the farmers highlighted some misgivings around the environmental control of the system. With the container being completely enclosed, not having fresh air, and being filled with water, these farmers were concerned with fungus growth. Cathy Harragian suggested that this environment, with little air circulation, may promote the
Finding #4: Farming Philosophy

The different farming practices and philosophies about food production also influenced the farmers’ interest in the Freight Farm product. During the interviews with farmers around Massachusetts, it was noted that opinions about the Freight Farm product varied widely. There are farmers that have no interest in the technology at all, and others that were enthusiastic and excited about the technology. Through taking a closer look at the types of farms and speaking with farmers, it is apparent that there is a large amount of diversity in the world of agriculture. This is easily seen when looking specifically at the interests of these farms and how they operate.

In our research we interviewed farmers from farms that are run for profit and some that are run to aid the community and not take in profits. The non-profit farm is about sustainability and providing food for the community. For instance a non-profit farm, New Lands Farm, is a community based farm that helps refugee farmers succeed in making a living off farming and providing a distribution channel through the New Lands Farm CSA. Ashley Carter, the agriculture program specialist for New Lands Farm, was quoted saying “people can’t live off lettuce,” which in the case of New Lands Farm is understandable because they work off the concept of providing food to the community that works the land.

The for-profit farms can be broken down further into groups based on their farming practices and philosophy. Many of the for-profit farms have moved into organic growing methods and are organic certified. The move to organics in this group is driven by community aspects; as well as being able to mark up organic food on the cost scale. People are willing to pay more for organically grown food, and some farms have moved to these methods in order to claim the higher markup. These farms can be further broken down into two groups based on the farmer’s farming philosophies. For instance, Julie Rawson—who was not interested in the technology—believes that growing should be done in the ground and that people need to get back to the dirt. Julie expressed that she disagreed with the concept of the Freight Farm and said, “I wish that understanding natural systems in an organic and holistic way, was where the
research would be directed” (Rawson, personal communication, January 29, 2013). This suggests that there is a group of organic farmers that have a farming philosophy that leans towards hydroponics being unnatural. In contrast to this, Ashley Howard of Heaven’s Harvest Farm, which is organically certified, is excited about the idea of the Freight Farm. He stated, “If all produce can be grown hydroponically with certified organic growing medium and fertilizer, I will start tomorrow” (Howard, personal communication, January 26, 2013). The majority of farmers that were interviewed clearly expressed that the Freight Farm would generate more interest if the system was organic. A couple farmers implied that the system could not be converted into an organic system because it would not be natural.

**Finding #5: Aesthetics**

The aesthetics of the Freight Farm was brought up a few times during interviews. The farmers suggested that a freight container is unsightly and they would not want it located near their houses. This seems to be a smaller problem that most farmers were not bothered by. One farmer that brought up the problem of aesthetics but also proposed a solution stated that, “the box is unsightly, this could be alleviated with painted murals” (Local Farmer, personal communication, January 30, 2013). This response showed that there is a problem with the aesthetics but farmers are willing to address this minor problem.

**Finding #6: Organic hydroponics**

In our interviews we found that farming philosophy and practices had a major impact on farmers’ interest in the Freight Farm. Many of the farmers in Massachusetts practice sustainable, organic, or “natural” methods. The Freight Farm’s produce is not organic due to the lack of a certified growing medium, fertilizer, and cultivation process. This was a major deterrent for many organic farmers but if the system were organic, they would likely have a greater interest. In order to address this issue we began researching organic growing methods and determining if a hydroponic system could be certified organic. This proved to be a complicated question.

When first researching organics we found the Organic Food Production Act (OFPA) of 1990. This Act lays out the requirements that need to be met in order to become certified
organic. The requirements reference soil many times throughout the act as seen in the statement below:

(1) SOIL FERTILITY. ---An organic plan shall contain provisions designed to foster soil fertility, primarily through the management of the organic content of the soil through proper tillage, crop rotation, and manuring (Organic Food Production Act, 1990).

When reviewing this Act it seemed as though an organic hydroponic system was not possible. However, we discovered documentation that implied that organic hydroponics was possible. A document from the National Organic Standards Board (NOSB) Crops Committee communicated, “In 1995, the NOSB stated that hydroponic production systems could possibly be conducted as organic operations as long as these systems met the other requirements of the national standards.” (National Organic Standards Board, 2008, p. 3) The NOSB is a Federal Advisory Committee with members appointed by the Secretary of Agriculture. The “Crops Committee” is one of six subcommittees of the NOSB. These findings contradict each other but with the NOSB’s document being published in 2008 it showed that hydroponics can likely receive organic certification.

In order to confirm that hydroponics could receive USDA organic certification, we contacted a USDA representative through email. The USDA representative that responded was an Agricultural Marketing Specialist from the USDA-AMS National Organic Program. The representative confirmed that organic hydroponics is possible stating, “There are a few hydroponic operations certified by NOP accredited certifying agents (ACA)” (USDA representative, email correspondence, March 27, 2013).

Finding #7: Increase awareness of government grants

One of the major concerns we heard about in our interviews revolved around the large initial investment required to obtain a unit. Many of the farmers we spoke with would be unable to get a unit because of this obstacle. Due to this problem, we looked into different grant and loan programs that are available to supplement the costs so that it may be easier for a farmer to purchase a unit. Under the USDA’s Sustainable Agriculture Research and Education (SARE) Program, “Massachusetts has received $6,645,104 to support 147 projects, including but
not limited to, 43 research and/or education projects, 12 extension projects and 66 producer-led projects. Massachusetts also has received additional SARE support through multi-state projects.” After speaking with a representative of the Massachusetts Department of Agricultural Resources (MDAR), it was confirmed that “any farmer engaged in commercial agriculture is eligible to apply.” There are many potential factors that qualify the Freight Farm for funding which include the water system, energy efficiency, and profitability. This proves to us that the availability of government funding is readily available once the proper programs have been found.

One particular grant program we looked into was the Agricultural Environmental Enhancement Program. This is a program run by the Massachusetts Office of Energy and Environmental Affairs. This particular grant aims to assist farmers that are looking to increase their efficiency and conservation practices. According to the MDAR website, “Farmers selected to participate in the program are reimbursed up to $25,000 for the cost of materials and labor necessary for the installation of the approved practice.” This amount of money would be a substantial way to decrease the startup costs of the Freight Farm.

Another program run by MDAR that could aid farmers interested in the Freight Farm is the Farm Energy Discount Program. In order to be eligible for this discount a farm must have less than 75 full-time employees. This requirement is easily satisfied by the farmers we interviewed. After completion of a detailed application and approval by MDAR the eligible farm would receive a 10% discount on their electricity and natural gas bills. This will help reduce the yearly costs associated with the Freight Farm making it easier to own over time.

While grants can be very helpful for farmers looking to purchase a Freight Farm there are also beneficial loan programs that could ease the financial burden of purchasing a unit. Through the Farm Service Agency (FSA) of the USDA farmers can apply for the Beginning Farmers Loan. In order to qualify for this loan the farmer must have less than ten years of experience owning and operating a farm. The specifics of the loan are discussed on the FSA website, and limit the loan based on the land value of the farm receiving the aid. Also, according to the 2007 USDA agricultural census, a farm would need to be less than 24 acres in order to be eligible. Based on the minimum interest rate (1.5%) and a principal of $60,000 it
would take less than seven years to repay the loan when interest is compounded monthly. This is determined by the estimated return on investment of Bibb lettuce being grown consistently throughout the year. Due to the 20 year term of the loan, farmers will be able to gain experience with the Freight Farm and begin generating profits with enough time to pay back the full loan. With a loan term of 20 years the Freight Farm should be generating profits well within the payback period making it a profitable investment for the farmer.

Each of the grants discussed above could help a farmer purchase of a Freight Farm. However, these funds are not limitless. We recognize that government funding is designated in certain amounts to different areas. The application process can also vary depending upon the program, and the acceptance process will most likely differ as well. While each of these factors may be setbacks, a successful loan or grant program could mean the difference between a farmer buying or not buying a unit.
5.0 Recommendations

Based upon the research we have conducted throughout the course of our project we discovered many common themes. As discussed in our findings chapter there are many suggested modifications to the current Freight Farm unit. The following recommendations are geared towards the Freight Farms company as well as any potential buyers. Each of these changes would increase the appeal of the unit, and possibly identify a new market for Freight Farms to explore.

Recommendation 1: Increase crop variety

Throughout the interview process we spoke with many farmers, and one of the most common discussion topics was the lack of highly profitable crops. The Freight Farm is currently set up to grow leafy greens such as lettuce and basil. While basil has a higher return on investment than lettuce, this is only one crop, therefore a wider variety is necessary. After the initial cost and yearly operating costs are taken into account, our interviews showed that farmers were generally uninterested in purchasing a unit because they perceived that the time required to begin a profitable operation would be too long. After analyzing the information collected from our interviews, we generated a list of target crops that could increase the profitability and produce a quicker turn around for the unit.

There were several varieties of crops suggested to us in our interviews. Mesculin lettuce was one of the most commonly mentioned crops. It is not very different from the leafy greens that are currently grown in the unit, but has a higher sale price. While it would require a different operation to continually grow mesculin lettuce due to the increased labor, it could be possible to generate higher profits which would counter the larger labor costs. Other crops suggested such as peppers and mushrooms would likely require modifications to the Freight Farm. Each of these crops would produce higher profit margins once implemented, as described by the farmers we spoke with.

As a result of recent legislature that has been passed, medical marijuana was a very common suggestion. Beginning with California in 1996, there are currently 18 U.S. states, including Massachusetts, that have enacted laws protecting individuals from prosecution of marijuana related crimes based on qualifications that vary by state. In Massachusetts, the
specifications for these laws have not been finalized, but are currently being created. When implemented, these laws will describe the policies needed to regulate the dispensary of medical marijuana. This includes the amount which could be possessed as well as how a dispensary will operate. Using the Freight Farm to produce medical marijuana would be highly profitable compared to standard agricultural products. In many states the laws regarding the production and distribution of medical marijuana are still in the process of being finalized. Therefore it is unknown how the Freight Farm could fit into this equation. By following the legal process in each state a dispensary could potentially obtain a Freight Farm. This use would require proper permitting and documentation.

While we recommend that the unit be converted for the growth of the plants discussed, we recognize that this may not be a simple solution. The success rate would be based on which plant was being grown, and different modifications would be required in order to have a successful operation. We also recognize that the crops mentioned within our interviews may not be the most profitable. We recommend that additional interviews and research into produce prices be done in the future in order to acquire a better list of crops. Generating this list could be used in limiting modifications of the unit and maximizing profits.

**Recommendation 2: Increase awareness of government grants**

Within our interviews one of the major concerns discussed by the farmers was the initial cost of a unit. Many of the farmers we spoke with operate small farms that do not take in profits which would allow them to make such a significant investment. In order to supplement the costs associated with the purchase and yearly maintenance associated with the Freight Farm we recommend looking into possible government funding for those interested.

There are many government programs at the federal and state level which are associated with agriculture and would be applicable to the Freight Farm. Under the Office of Energy and Environmental Affairs, Massachusetts distributed approximately $8.6 million dollars in 2010 to fund seven different grant programs. By this data, it is apparent that state funding is available depending upon a farmers operation. While the Freight Farm does not fall under all of these categories, it has been confirmed to be applicable for some of the programs.
While the production process may have some differences, the unit still qualifies as an agricultural system. We would recommend that anyone interested in obtaining a unit talk with a representative of their state’s agricultural department to see which loans could be specifically available. Also, the USDA is another great resource for obtaining grant and loan money. The foundation directory online is another beneficial tool for searching for grant money and has many criteria to look through. Overall, each of these methods would enable a potential buyer to possibly receive funding to subsidize the cost of the Freight Farm making it easier to invest.

**Recommendation 3: Organic hydroponics**

Another concern discovered through our interviews was the lack of an organic certification. Many of the farmers we spoke with demonstrated a growing interest towards organic farming. Some farmers are trending towards organics because it has the prospect of higher profits. A portion of these farmers are also choosing to grow organically because of societal pressures from consumers. Regardless of the reasoning behind this switch, the trend is clear and should be noted as another challenge, and opportunity, for the current Freight Farm model.

While demand for organics is increasing, it is unclear whether or not it is possible to make the Freight Farm organic. According to the National Organic Program (NOP), a branch of the USDA, “organic operations must demonstrate that they are protecting natural resources, conserving biodiversity, and using only approved substances” (National Organic Program, 2013, p. 1). The process for gaining organic certification can be somewhat time consuming and even costly depending upon the agency which qualifies an operation as organic. There are multiple differences between standard farming and hydroponic farming but it has been confirmed by the USDA that it is a possibility.

When considering organics, one of the main characteristics that certifies a system is the use of soil. In fact, there are many countries around the world that require soil in order to be organic. While soil may be a requirement in other countries, the USDA allows the use of coco fiber or perlite as a growing medium in a hydroponic set up. As well, there are different types of organic certified liquid nutrients which are acceptable within the United States. While these
products may be more expensive than traditional hydroponic materials, the sale of organics would increase profits as well as the general appeal to local buyers.

In addition to the substrate and nutrients used, there are other aspects of a hydroponic system that need to be certified as organic. Firstly, all of the materials used must be certified as being food grade. This is especially important for the plastics used which must not contain dyes or recycled plastics that are deemed harmful to humans. Also, the food crops itself sometimes require specific plastics that do not allow any leaching of plastic into the foods. Acceptable types of plastics for use with food are high density polyethylene, polypropylene, and polycarbonate. While not every iteration of these plastics are food grade, the manufacturer can provide assurance as to whether or not it acceptable.

Another aspect of organic certification is the usage of pesticides and fertilizers since these are the common deterrents to organics. These barriers can be overcome through different means. The use of the natural substances pyrethrin and azadirachtin have been approved by the USDA. There are also other synthetic compounds which are acceptable, by USDA standards, “if they are relatively nontoxic combinations that include minerals or natural elements, such as copper or sulfur.” Organic fertilizers are another obstacle to organic certification but there are many types which have been approved for this process. Some possible options include seaweed, rock dust, mined potassium sulfate, and soil microbes. Each of these are main ingredients in many different types of fertilizers that have been certified organic.

Overall there are many different materials that go into the operation of a Freight Farm and many are not organic. However, there are many organic alternatives to these materials which could be investigated to make the Freight Farm organic. In general the materials used in the setup have to be free of harmful chemicals and come from natural sources. There is also a clause which allows the use of non-organic certified materials if there are no existing organic alternatives. In the end if takes a small amount of research and some heavy implementation but the Freight Farm could most likely become organic certified by the NOP if the proper investment were made.
Hydroponic farming is not a new idea and the creation of an organic standard for operations similar to the Freight Farm is already in place. Sweet Water Organic, a company based out of Milwaukee, WI has started an aquaponics company out of an abandoned industrial facility. Aquaponics, a system that was also suggested within our interviews, uses a system which utilizes fish waste as a fertilizer for the plants. The water is then filtered by the plants and continues to be used for the fish. Within their operation they also take advantage of lady bugs and praying mantises to control attacks from pests. The company has a setup which closely resembles the Freight Farm and is a great example of a hydroponic growing system which has been certified organic.

Organic certification can be a difficult and time consuming process for many organizations throughout the United States. According to the NOP it takes at least three years without the use of prohibited materials to obtain organic certification and certification fees can cost up to several thousand dollars. We recognize that the transformation process would not be very easy to complete; but if were done successfully, the larger profits could make the investment worthwhile.

Concluding Thoughts: Technology and Society

Throughout the process of completing our project we each learned many key lessons. In this section we will discuss the driving factors behind a profitable business as well as what can be learned from our research.

The Freight Farm has the ability to create a more sustainable agricultural system which reduces energy costs while increasing production. This aspect of the Freight Farm is not limited by geographic location because it is very versatile. The system requires small amounts of land as well as small amounts of energy. This is due to the size and efficiency of the unit. Realizing the versatility of the system and the positive impacts it brings to any area is key in understanding the possible success of the Freight Farm.

While the Freight Farm has a large amount of versatility in terms of increased production, it also offers great benefits for an extended growing season. There are many areas throughout the world where agriculture is difficult due to the environment. Places like New England have less light and colder weather during the winter months which prevents many
farmers from growing year-round. There are other areas where soil conditions are poor and do not allow for standard agricultural production. Other areas of the world have difficulty obtaining water for agriculture usage because large amounts of land which could produce the same amount of food as a Freight Farm require much more water. These are key issues that the Freight Farm addresses which could be used for expansion into other areas.

This project would have likely looked different in another location. A large part of our research involved realizing the growing trends towards organics and small farms. Different areas of the world have different set ups for agriculture already and this would highly effect the successfulness of a Freight Farm there. Many farmers noted that the Freight Farm was great in principle, but would be difficult to implement. The expensive nature of the unit was discussed as well as how the food grown inside of the Freight Farm would differ from those crops grown naturally in the soil. We learned that there any many socioeconomic factors that determine someone’s opinion of the Freight Farm. Income, farming philosophy, and farmer age were some of the main reasons we found adversity to the Freight Farm within our interviews.

Overall we learned many lessons from our project. Through our interviews we caught a glimpse of the changing farming system in New England. Based on the initial responses we received in our interviews we feel confident that the Freight Farm can be continually improved upon and expand into new markets. The success of the Freight Farm is based on many different factors of the environment. The way in which it fits into the current agricultural system of a certain area will be the determining factor in analyzing its true versatility. We hope that further research can be conducted to determine additional locations where the Freight Farm can be successfully implemented to help farmers while also aiding the food system in that area. This includes the possibility of a chain of units growing a variety of crops which could be tied together in a style similar to a food hub.

Looking to the future, we feel that the Freight Farm has great potential and that there is still more to be done to improve the system. Initially, a deeper look into organic hydroponic materials would be beneficial. Doing a cost analysis to examine how much more money could be taken in by organic crops and how much more it would cost for the supplies would show how much better an organic unit is. Besides the Freight Farm, we suggest more interviews with
many different farmers across a wider sample size. Discussing the unit with different types of
farmers would be helpful to gain more opinions and suggestions for improvement. The cost of
the system was seen as one of the largest obstacles to obtaining a unit. Therefore, we suggest
researching additional grants through the Foundation Directory Online as well as contacting
additional agencies of state and federal governments. A look into additional markets for the
Freight Farm could be beneficial as well to determine where the company could expand. A large
customer base could be developed through this research to improve profit margins and
continue spreading the sustainability of the Freight Farm.
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Appendix A: Interview Protocol

Good Afternoon, (introduce yourself)

(introduce project)

So I’m a part of a project group at WPI which is working with a local start up known as Freight Farms. Our main contact is Brad McNamara, a graduate of Northeastern University who is working on this concept at Clark University. We are looking into seeing how feasible his idea may be for farmers in the area, so I’d like to begin by talking about how you got into farming.

Basic Questions: (build a rapport with the interviewee) These are example questions based on the direction of the conversation, keep it flowing naturally and continue to build rapport

When did you start farming?

Is anyone else in your family a farmer or involved with agriculture?

What size farm do you have?

What types of crops do you normally grow?

Do you do anything else besides farming? What are you other hobby’s/interests?

Follow Up Questions:

How many people work on your farm?

How do you currently distribute the goods you grow? (CSA, restaurant, food stand, etc.)

Would you be able to continue selling your products in this way if you were growing year round?

Do you have any set up for year round growing?

If yes: What do you have? How efficient is it? Is it more difficult than your regular season growing techniques?

If no: Do you have any interest in year round growing?

Explain the features of the Freight Farm. Efficiency, yield, cost, etc. (have the fact sheet in front of you)

- Use specifics but be sure they will understand what you’re saying (ex: saying the exhaust fan runs at 120 watts for 2 hours every day is worse than saying, the exhaust fain costs $5 a year to run.)

Explain the freight farm contains a lot of automation so the work put into will most likely be less intense than normal farming due to the technology.

Based on the cost of the Freight Farm, would you consider purchasing one if it were available? (Discuss research into government-funded grants for these types of technologies)
Would the aid of government grants make it easier for you to consider buying one of these?

If they seem interested find out specifics. What is it that really sells it to them.

If they aren’t interested find out why. What features turn them away from this product.

(after preliminary interviews we can discuss what other farmers said and see what the next interviewees think of that)

**Ending Interview:**

Thank you very much for your time, your responses will be very helpful with our project. If we need, would it be alright for us to contact you again for a follow interview once we collect more data.

Ok, thank you very much for your time, we really appreciate it.
Appendix B: Freight Farm Pictures
# Appendix C: Freight Farm Operating Costs

## ENERGY

<table>
<thead>
<tr>
<th>Watts</th>
<th>hrs/day</th>
<th>hr/yr</th>
<th>watts/yr</th>
<th>Annual Kilowatt hrs</th>
<th>Annual Cost</th>
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<td>12,902,400</td>
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<tr>
<td>heat/ac</td>
<td>3000</td>
<td>18</td>
<td>6,048</td>
<td>18,144,000</td>
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<td>672</td>
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<td>Blowers</td>
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<td>10</td>
<td>3,360</td>
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<td>Main Pump</td>
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<td>12</td>
<td>4,032</td>
<td>483,840</td>
<td>$33</td>
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<td>Prop Pump</td>
<td>100</td>
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<td>336</td>
<td>33,600</td>
<td>$2</td>
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<tr>
<td>Prop Lights</td>
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<td>10</td>
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<td>336,000</td>
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<td>672</td>
<td>50,400</td>
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<td>1,344</td>
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<td>Totals</td>
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<td></td>
<td>44,589,696.00</td>
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## Water

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<tr>
<th>Annual Gallons</th>
<th>Monthly Cost</th>
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<td>3960</td>
<td>$2.24</td>
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<tr>
<td>Supplies</td>
<td>Monthly</td>
</tr>
<tr>
<td>---------------</td>
<td>---------</td>
</tr>
<tr>
<td>Nutrients</td>
<td>$17.50</td>
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<tr>
<td>Grow Medium</td>
<td>$80.00</td>
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</table>

<table>
<thead>
<tr>
<th>Labor</th>
<th>Monthly</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>@min wage 8.75</td>
<td>$700.00</td>
<td>$8,700.00</td>
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Appendix D: Freight Farms Marketing Sheet

THE NEXT GENERATION OF FOOD SUPPLY
Growing food locally is the most sustainable way to shift from a broken global food supply system. But local food production has always had difficulties providing fresh produce throughout the year to the larger commercial market. Until now...

Freight Farms™ is a turnkey solution that creates local food supply at a commercial volume. Freight Farms introduces a scalable farming platform that can be operated anywhere. By up-cycling shipping containers into a source for high yield crop production, Freight Farms make food accessible in environments where farming has never been possible.

IMPROVED PERFORMANCE
Profitable crop production has never been this easy. Freight Farms have eliminated the inefficiencies associated with commercial farming and streamlined every element of the growing process, from seed to harvest. Each unit is outfitted with advanced climate technology that creates the optimal growing conditions needed to maximize any harvest. The configuration of the system delivers high-quality production at a low cost of operation and uses a fraction of the energy compared to traditional and greenhouse production. Unlike other methods of commercial farming that grow food by the square foot, Freight Farms grows food by the cubic foot. This allows up to 3000 plants to be harvested at one time in a single unit.

CHOOSE FROM A WIDE VARIETY OF CROPS
leafy greens  (Lettuce, Kale, Spinach, Arugula, Basil, Oregano, Mint, Parsley, etc.)

vine crops  (Tomatoes, Cucumbers, Peppers, Squash, Beans, Zucchini etc.)

mushrooms  (Shiitake, Baby Bella, Portobello, Oyster, etc.)
GROW FOOD, ANYWHERE
Freight Farms can be implemented with existing business infrastructure or used as a way to create new market opportunities. Freight Farms can transform unused space into a way to grow your business and/or community. Easily begin commercial farming without any redevelopment to existing real estate. Additional Freight Farms can be stacked to scale-up production without using a larger footprint.

HARVEST THE BENEFITS
<table>
<thead>
<tr>
<th>No Pesticides</th>
<th>Superior taste, quality, appearance, uniformity, and extended shelf life.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Herbicides</td>
<td>No weeds, no cultivation, no soil borne diseases or insects.</td>
</tr>
<tr>
<td>Smaller Footprint</td>
<td>Less water and less energy required.</td>
</tr>
<tr>
<td>Greater Yields</td>
<td>Optimum growth, year-round growing season, maximum plant nutrition.</td>
</tr>
</tbody>
</table>

FARMING, REDESIGNED.
Freight Farms produce big results for the local market. The state-of-the-art production technologies optimize the harvest cycle for any grower and puts food supply within everyone’s reach. The human centered design benefits a wide variety of users, including but not limited to, institutional food service providers, schools, restaurants, farmers, grocery stores, disaster relief efforts, wholesale produce distributors and developing communities.

Freight Farms can be operated with minimal training and equipped with technology to optimize workflow. Users can monitor the unit remotely and control every element of the system from their mobile devices. Harvest support services are available for customers looking to maximize their growing potential.

For more information please contact info@freightfarms.com
Appendix E: Food crops grown under protection and sold
Massachusetts, 2009, Census of Horticultural Specialties (Census of Horticultural Specialties, 2009)

- Total for all food types
  - 67 operations
  - 329,000 sq ft
  - Production: Values withheld for Total and hydroponics
  - Values of sales (USD):
    - All sales: 4,342,000
    - Wholesale: 3,126,000
    - Retail: 1,216,000

- Cucumbers
  - 13 operations, 10,000 sq ft, 39,000 (30/9)

- Herbs, Fresh
  - 17 operations, 41,000 sq ft, 219,000 (188/31)

- Lettuce, All
  - 11 operations, 16,000 sq ft, 57,000

- Peppers, All
  - 11 operations, 13,000 sq ft, 19300 lbs, 44,000 (6/37)

- Strawberries
  - No data

- Tomatoes
  - 61 operations, 225,000 sq ft, 990,000 (No split data)

- Other Food crops grown under protection
  - 4 operations, 25,000 sq ft, 2,993,000 dollars (Unspecified crops)

Average profit per sq ft
- Cucumbers: $3.9
- Herbs, Fresh: $5.34
- Lettuce, All: $3.56
- Peppers, All: $3.38
- Tomatoes: $4.4
- Other crops: $119.72

Based on the total data:
- 4.342 mil / 67 operations = 64k per year average for greenhouse crops
- 64k/4 = 16k during winter (3 months), on average
- Discounting the unspecified ‘mystery crop’:
  - 1.349 mil / 63 operations = 21.4k per year average for greenhouse crops
  - 21.4/2 = 10.8k from October to March (six months)
Appendix F: Greenhouse Construction Costs
Values of greenhouse costs based upon various sources

- Costs: USD $ 5700 - 8700 (+$4224) (Flores, 2006), Estimated 10-12 Days w/ 6 Laborers (528 hours assuming 11 days and 8 hour work days, opportunity cost of $4224 assuming minimum wage of $8/hour), Polyethylene plastics, 4,245.5 Ft², requires welding

- Average cost of at-home greenhouse : $17,260 (small data sample) (Home Advisor, Ongoing)

- Cost: $20,120 (1990 estimates) Double layered polyhouse, 2660 sq ft (Service)

- Cost: $15,171, double layer polyethylene, 2,880 sq. ft. of growing space (Robbins, Unspecified)

- Cost: Averaged $5.00/ft², 4000ft² for $20,000 (Pena, 2005)
Appendix G: Data on Greenhouse Energy costs
USDA Energy Self-assessment for Greenhouse energy costs (Greenhouse Energy Self Assessment, Ongoing)

Zip code: 01609 (Worcester, MA)
- No Thermal Curtain
- Double wall Poly film
- No foam insulation
- Unit Heater – Forced Air – High Efficiency Separated Combustion
- Underbench heat distribution
- Tight greenhouse (not leaky)
- Average day temperature: 65 degrees Fahrenheit (Sanders, 2001)
- Average night temperature: 50 Degrees Fahrenheit
  - Assuming day/night temperature difference of 15 degrees Fahrenheit
- One Controller: Yes
- Roof section / Bay Width : 22 ft
- Greenhouse Length: 150 ft
- Number of roof sections: 1
- Ground to peak height: 10 ft
- Side wall height: 6 ft
  - Greenhouse size taken from detailed online building plans (Flores, 2006)
- Perimeter Footing Insulation: 0
- Infiltration heat Losses: Tight, New
- Fuel: Heating Oil, $4/gal
  - http://www.massenergy.org/heating-oil/prices
- Yes master controller
- Cool season crops
- Estimated annual Fuel costs: $12,243/year ($3.71/sq.ft)
- Potential savings:
  - Thermal Curtain
  - IR inhibited double poly glazing
  - 2 inch thick, 2 feet deep foam insulation around perimeter
  - Heating system: Replace with High efficiency condensing heating system
  - Heating distribution: use underbench or in-floor
  - With all recommended changes: $3,525 costs per year ($1.07/sq/ft.)
- Estimated Freight Farm LGM costs: $2299/year, about 3000 planting sites