Assessing the Potential Environmental Impacts of Controlled Environment Agriculture in Detroit and the Future of This Industry Based on Local Food Trends

Assessing the Potential Environmental Impacts of Controlled Environment Agriculture in Detroit and the Future of this Industry Based on Local Food Trends

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Abstract

The main objectives of this research project were to assess the capacity for Detroit to be a model for a variety of methods of urban agriculture; to assess the sustainability and environmental impact of an urban CEA farm; to create an understanding of how much urban food production is necessary to improve the sustainability of our current agricultural system; and to assess consumer demand for local food and sustainability of local food systems.

More than half of the global population lives in urban areas that must import resources, so this research assesses the potential of urban food production. One way for a city to provide local food is through controlled environment agriculture (CEA), where soil-less growing trays are used indoors, and crops can be grown year-round using climate control. The primary research questions is whether CEA is more sustainable than traditional agriculture. Hypotheses include: Detroit can be used as a model for CEA farms; CEA is a sustainable way to produce locally-grown vegetables in urban areas; demand for local food is growing and will support future marketability; and local food systems are more sustainable than business-as-usual agriculture based on emissions and energy use for production and transport.

Methods included interviewing stakeholders, analyzing data from two Detroit CEA farms and from relevant studies assessing the energy use and yield of a theoretical CEA farm. I interned at an urban farm in Lansing in order to gain information on the functioning of the local food system. Based on the Detroit CEA farms and studies on

CEA environmental impacts, it was found that the energy use of indoor agriculture is highly intensive, and may not be advisable without the use of renewable energy and stacked growing trays (vertical farming). Methods must be used that are more energy efficient. New data was created that built upon a study that compared energy use and yield of CEA and traditional farming. The findings were that although indoor hydroponic agriculture is energy intensive, using CEA methods with stacked growing trays increases yield at a higher rate than it increases energy use, because the main use of energy is for heating and cooling, and tray stacking doesn't change the amount of heating and cooling needed. Although indoor farms currently are not in a position to have an impact on lowering food transport emissions from industrial agriculture, there is future potential based on use of renewable energy and increasing customer demand.

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Chapter I

Introduction

In 2008, for the first time, the majority of people on earth lived in cities. In 2014 that percentage increased to 54% (United Nations, 2014). The World Urbanization Prospects Report (2014) predicts that number will climb to 66% by 2050 and continue to grow. This may cause the resources available in urban areas to become scarce, and a large scale implementation of sustainable urban agriculture may be needed to relieve pressure on American farmlands and provide locally-sourced food to urban areas.

Research Significance and Objectives

This research assesses whether controlled environment agriculture (CEA) is actually more sustainable than traditional agriculture, taking into account both production and transport, and whether it can effectively reduce emissions, land use and water use. CEA farming, which uses stacked growing trays, could potentially help reduce food insecurity by providing local fresh produce to areas of the city with less access to grocery stores, in addition to the potential environmental benefits (Despommier, 2010).

Detroit is a reasonable location for this assessment because it has tens of thousands of vacant lots and buildings that could be assessed for agriculture (Mogk, 2010). Small-scale urban agriculture in Detroit is thriving with over 2,000 community farms (Resnikoff, 2014). There are now examples of hydroponic and aeroponic CEA farms, making Detroit a potentially excellent system to analyze the impact of a small-scale integrated urban agricultural system. If found to be beneficial, the results of this research could then be used to foster overall resiliency in cities. The initial steps towards this are to assess practical sustainability of CEA farms and of the local food movement. My overall study objectives were to:

1. Assess the sustainability of a CEA farm compared to traditional farming, using life cycle assessment (LCA), including all aspects of production, harvest, processing, transport, consumption and eventual waste.
2. Quantify how much urban food production is necessary to significantly reduce emissions, food costs, use of farmlands, and agricultural runoff.
3. Assess whether demand for locally sourced food will be enough to allow large-scale CEA to enter the market, and whether eating local is actually feasible and better for the environment.
4. Create a model of an urban agricultural system to be followed by other cities to address the issue of increasing populations and overuse of resources.
5. Assess the role of individual citizens and nonprofits in organizing, funding and implementation of CEA farms in vacant buildings.

Background

Global population growth is straining the natural resources of the planet in several ways, including the agricultural system that must provide food for all 7.4 billion of us (PRB, 2016). It is estimated that in order to feed the growing population we will have to grow more food in the next 50 years than has been collectively grown in all of human agricultural history (Bourne, 2015). The current systems of food production and transportation both add greatly to global CO_2 emissions; traditional agriculture overuses water, chemical pesticides and degrades natural ecosystems. The amount of farmer's markets in the US increased 350% between 1994-2013 (USDA, 2014), and millennials are the greatest consumers of organic produce (Paul, 2016).

With an increasing urban population worldwide, a shift towards preparing for the effects of climate change in cities is crucial for the future. These urban centers import resources from surrounding rural areas because human populations are densely concentrated; many cities used up their own local resources long ago, as the popularity of urban living increased (Makin, 2009). As part of the preparation for the possibility of a new climate pattern, it may be beneficial for cities to be able to produce some of their own resources, including major efforts to grow food locally (Despommier, 2010). Since the highest populations are in cities, it makes sense for them to grow their own food if possible, with one limitation being the large space that is needed for traditional agriculture.

Today's global economy and trading structure means that food can easily be transported around the world, enabling you to walk into a grocery store in Boston and buy a grapefruit grown in Mexico, artichokes from Spain and wine from Australia. In 2007 the NRDC stated that the average American meal had five ingredients from other countries, and that 25% of the food we consume was grown in China. Even produce grown domestically is transported 1,500 miles on average before it reaches the store. (NRDC, 2007). Many types of fresh produce are imported from other countries even when they are in season locally, adding to CO_2 emissions from the use of trucks, ships and planes. Even though California is a major agricultural grower for the country, the importation of fruits, vegetables and nuts into the state in 2005 was measured to produce 70,000 tons of CO_2; the global estimate for food transport emissions that year was 250,000 tons CO_2, similar to the amount produced by 40,000 cars (NRDC, 2007). This report assesses the possibility of whether urban CEA farming can reduce emissions from both food transport and production, in the LCA context that takes all elements into account. A comparison of emissions from the power plant producing the electricity is likely necessary.

According to the USDA, agriculture used 40% of US land in 2012, or 915 million acres. Nearly half of this land (415 million acres) is pastures for livestock (USDA 2014). Traditional farming methods use immense amounts of water, and according to UNESCO, agriculture (conventional and organic) uses 70% of the planet's fresh water. It also creates chemical runoff and CO_2 emissions and degrades natural ecosystems. In many places in the world, agriculture is causing deforestation and desertification because of the use of highly unsustainable farming practices. Development threatens natural lands as well, to the tune of 6,000 acres per day worldwide (Trust for Public Land), so protecting animals habitats, original forests and natural grasslands is of the upmost importance. Agriculture produces 9% of the U.S. GHG emissions (EPA, 2014).

Food production accounts for a much higher percentage (83%) of emissions within agriculture than transport (11%) (Weber & Matthews, 2008) (Figure 2). So while eating local can have an impact on reducing food miles, it is not nearly as much of an impact as changing the way that we produce food. Their recommendation for this change is for people to eat less red meat and dairy products, which produce 150% more

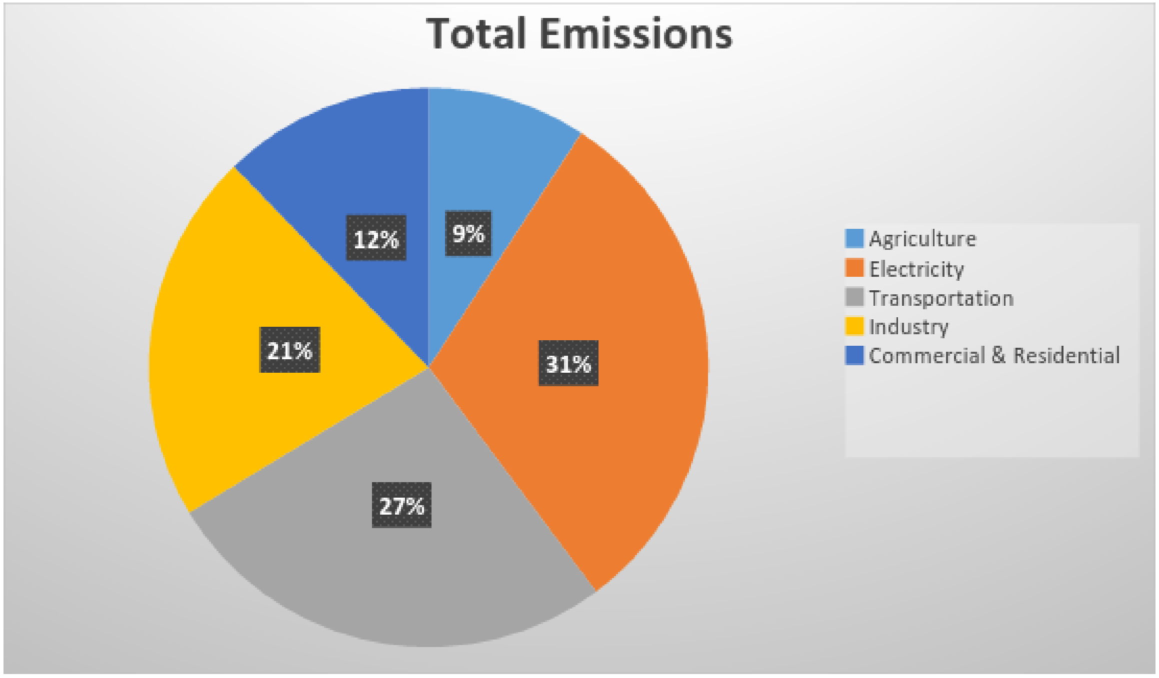

Figure 1. Total US emissions in 2014 (Adapted from EPA, 2014).

that a consumer can have an impact, along with supporting a more large-scale change in food production that will produce fewer emissions from the start. Since CEA does not include meat production, it could organically encourage eating more vegetables by sheer convenience as well as education.

The National Resource Defense Council (2007) estimates that "between 1968 and 1998, world food production increased by 84 percent and the population by 91 percent, but food trade increased 184 percent". The Food and Agriculture Organization (FAO) of the United Nations supports global food trading as it strengthens global markets, promotes growth potential for developing economies, and future benefits of increasing trade opportunities (FAO, 2015). However, the FAO also supports urban and peri-urban

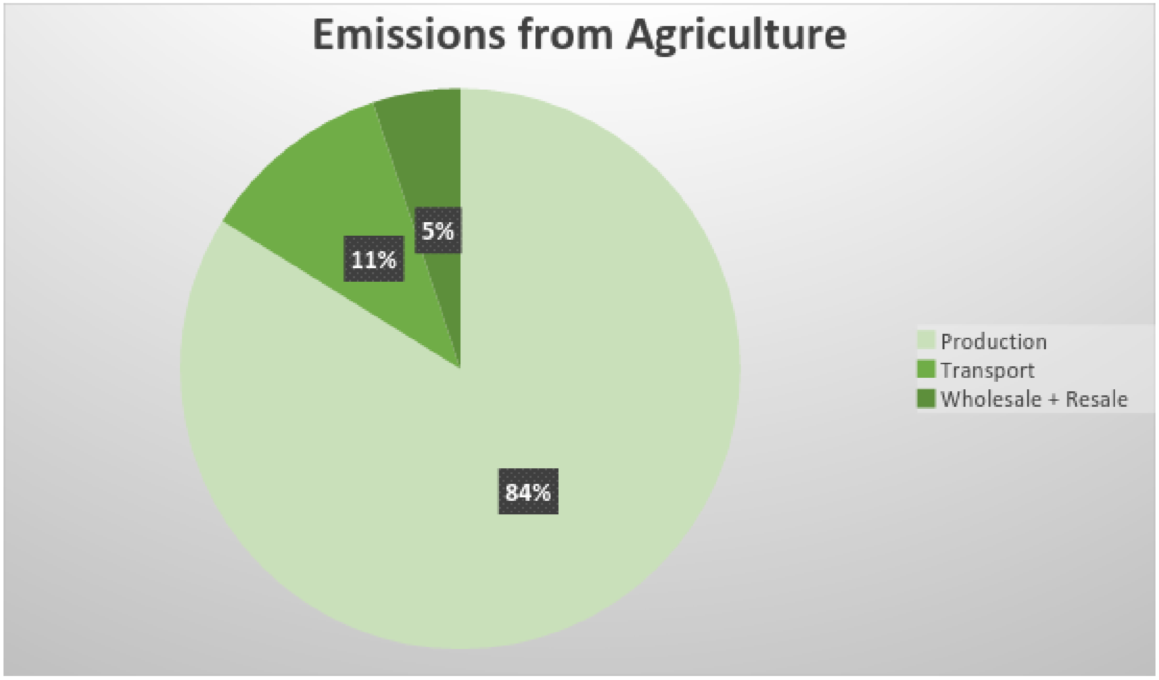

Figure 2. Emissions from agriculture in the US (Weber & Matthews, 2008).

agriculture, especially in the developing world (FAO, 2015), claiming it promotes food security, provides employment for women, and reduces costs and environmental impacts of transport and packaging. Trends in the ballooning of global food trade is a major reason to assess innovations in agriculture that allow food to be grown in new ways, to meet the demand of a growing population in a way that is environmentally sustainable. Urban CEA may be an important part of reducing the food trade and lowering the emissions it causes.

Since concerns have been raised on the huge increase in global food transport, it is important to consider whether local food is actually more sustainable, as well as the market trends on whether local food will remain in demand. The National Restaurant Association's "What's Hot Culinary Forecast" of 2016 lists the number one trend of restaurant-goers as “sustainability”, according to a survey of 1,600 chefs. The same survey in 2017 lists the top trend as “hyper-local sourcing”. This is based on observation and somewhat in opinion, but the restaurant industry should be viewed as having a relatively accurate read on the industry trends. In 2012, 52% of US consumers surveyed said locally-sourced produce was more important to them than organic (Mintel). Between 1994 and 2013, the number of farmer’s markets increased 350%, as demand rose for direct-to-consumer options (USDA, 2016). But will these trends continue? And are local food systems truly more sustainable, or are we caught up in a food trend that doesn’t reflect what’s accurate? Considering transport of food accounts for only 9% of agricultural emissions, dwarfed greatly by production emissions, it is possible that a locally-sourced food is not enough to help the overall system.

Overview of CEA Farming

Despommier (2010) discussed the many benefits of CEA farming, including less space needed and higher yields; reduced use of water and pesticides; and year-round, weather-resistant growing. Many studies have been published on the feasibility of different CEA farming techniques, but Despommier (2013) cites only six functioning around the world; two in Chicago, and one each in Vancouver, South Korea, Japan and Singapore. A basic internet search in 2017 puts that number in the dozens in just the United States, with much interest around the world as well. The three methods currently in use in CEA farming are hydroponics, which uses only a nutrient-rich water solution and no soil; aeroponics, in which the roots grow with no water or soil, but are sprayed consistently with a nutrient-rich water solution; and aquaponics, which is a means to grow plants underwater, using co-habitating fish for nutrients. Hydroponic and aeroponic farms sometimes use stacked trays for more growing spaces for higher yields and LED lights that mimic the energy from the sun.

Hydroponics have been in practice since the 1930s, and their use in CEA farms has become more popular in the last few years due to the invention of LED lights and more advanced control systems for those lights as well as for water and nutrient dispersal (Despommier, 2013). These advancements are continuous, and the technology is advancing and becoming more readily available. An example of the streamlining of this technology is that there are currently two companies that sell shipping containers converted into small CEA farms. Farm in a Box and Freight Farms supply all necessary materials and instructions for the buyer to have a fully functional, cutting-edge farming technology in their backyard. Freight Farms even has a Farmhand App, so a smart phone user can monitor their farm from anywhere (www.freightfarms.com). As it seems that for good or ill, this technology is becoming mainstream, studies on their environmental impact are necessary.

Energy, Water Use and Yield of CEA

It is possible for CEA farming to have a higher yield per acre than traditional because of a year-round growing season. Outdoor farms can typically do three harvest per year, but indoor farms can do up to eight, especially with leafy greens (Despommier, 2013). As one example, strawberries can have a yield of about 30 times higher than traditional, and water use is typically 70-80% less with indoor agriculture (Despommier, 2013). Many states in the southwestern U.S. use excessive irrigation to grow crops because the natural environment of those places and amount of rainfall does not support the type of agriculture needed to feed the region's increasing population.

Arizona, for example, diverts 69% of its freshwater use to agriculture (Barbosa, 2015). Concerns over the sustainability of this amount of water use prompted a study on the difference in water use, energy use, and yield of CEA hydroponics against traditional agricultural methods. It was found that CEA had a yield of 11 (+/-1.7) times higher (Barbosa, 2015). This study did not calculate the yields of stacking these hydroponic trays which would become vertical farming and multiply the amount of crops able to be produced. If hydroponics are done indoors, it does not require pesticides and has a year-round growing cycle. Lettuce is the second largest crop yield in the U.S., after onions (Barbosa, 2015), and it grows well in hydroponics and aeroponics. Many studies use it as a primary example of the first crop grown by functioning CEA farms, for example Farmed Here, in Chicago. Further results from the Barbosa study show that although the hydroponic yields are much higher per unit of space they actually require more energy (2015). Regarding the higher energy requirement found for hydroponics, a greenhouse was used so the plants received solar energy, but they also utilized "temperature controls, supplemental artificial lighting and water circulation pumps" (Barbosa, 2015, pg. 6881), all of which require energy sources. The energy need could be even higher with the exclusive use of LED lights. This was assessed when considering the positive benefits of this type of growing, and whether indoor farms can be designed to be more energy efficient than what was found in this study.

Potato minitubers were grown in an indoor greenhouse in Spain and used to compare (CEA) hydroponic and aeroponic cultivation methods (Ritter, 2001). One overall positive effect was that harvesting root vegetables was much less intensive and in fact the plants could keep growing because the root system didn't have to be completely removed, such as with traditional soil-based farming. It was also found that the aeroponic system had a yield of 70% higher but the minitubers were 33% smaller than in the hydroponic system. This shows that aeroponic systems can have higher yields but since the roots are not supported by soil or water, the resulting vegetables will be smaller (Ritter, 2001). The yield vs. the weight of the potato essentially evens out (so would feed the same amount of people), showing that using aeroponics to grow root vegetables specifically may not be necessary, unless other benefits are identified.

Table 1. Advantages of hydroponic and aeroponic growing methods (Ritter, 2001).

Hydroponic Advantages	Aeroponic Advantages
Plants can grow larger because of support More cost effective Less technical; more user-friendly	Lighter weight system Uses less water Easier temperature control Easier root-zone manipulation

The advantages of aeroponics are that it is a lighter weight system, uses less water, and allows modifications to the root zone (He, 2015). Controlling the temperature of the roots and the CO2 levels can allow the farm to grow plants from all different climates. This is easier than with CEA hydroponics, because air temperature is easier to control than water temperature. CEA being able to grow more plants from other climate zones would be a big advantage in selling to the large-scale markets that demand them. The potential benefits of CEA hydroponics suggest that traditional farming could be used less, but not phased out completely. An overall integrated system utilizing traditional methods (conventional and organic) as well as CEA could lead to an overall more sustainable food system, as long as the environmental benefits of CEA are properly studied.

Peri-urban agriculture has also been identified as a potential part of a more sustainable system, and includes agriculture in suburbs, farther from city centers. This is relevant because of emerging mega regions that are increasingly defining the urban and suburban landscape. An organization called America 2050 identifies eleven mega regions in the US, containing multiple cities that are connected through their shared economic and transportation systems as well as natural resources. One of the biggest is the Northeast region, which stretches from Boston to New York, Washington DC, Baltimore, and Philadelphia, and includes all regional suburban areas of these cities. The Great Lakes region is to the west and the major cities involved are Detroit, Chicago, Pittsburgh, Cleveland, Minneapolis, St. Louis and Indianapolis. There are also many smaller cities in the Great Lakes region that are interconnected, representing a total population of 55.5 million and accounting for 17% of the US GDP (America 2050, 2017).

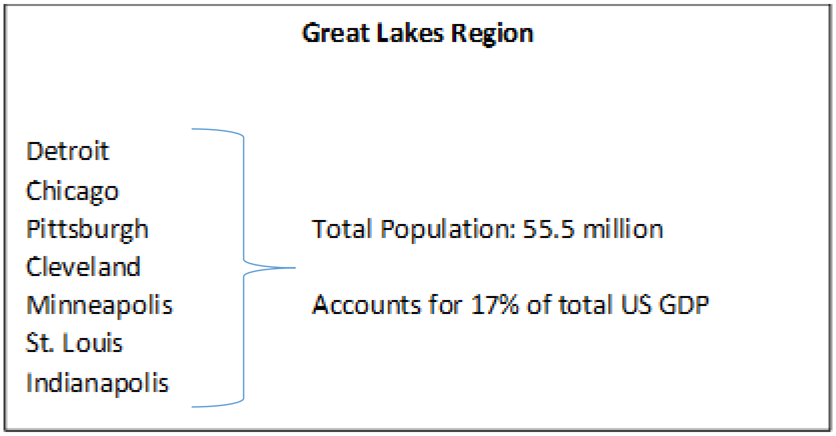

Figure 3. Demographics of Great Lakes Region (America 2050, 2017).

Imagine that between these cities there used to be forests or grasslands or whatever was the natural shape of the land. The first suburbs go up around the downtown area, and the overall population grows. As people desire more and more access to natural environments and small town feel in addition to access to the culture, community and economic benefits of a city, suburbs grow farther out from the center with a more elaborate system of highways for cars and public transportation. As suburbs flow out in every direction from neighboring cities, more highways are made to connect those neighboring cities, in addition to vast new areas of shopping malls, business hubs and general commerce. All this development has an effect on plant and animal life, and disrupts natural drainage of stormwater.

Peri-urban farming could be used in areas of urban sprawl, assuming that local food systems are found to be sustainable. Vacant buildings and lots are likely to exist and can be repurposed, with careful strategic planning as to other needs such as affordable housing. Each farm can provide for a certain local area so that transportation costs can be reduced, and more food per acre can be grown in CEA buildings than traditionally in soil. Small cities could also benefit from urban agriculture, especially ones that are struggling with high unemployment and lowered populations such as Flint, MI, Worcester, MA, Syracuse, NY and many others. Once booming with industrialization, many small American cities suffer from post-urban decay and the movement of the middle class to either suburbs or to bigger, more productive cities. Peri-urban agriculture could help to make these places more self-sustaining, as well as bring back jobs and help struggling local economies. Jobs in this industry might be appealing, because it is different from traditional farm work and more like working in a high-tech factory. Newark, New Jersey has recently been in the process of opening AreoFarms, a large CEA (vertical, hydroponic), with the express purpose of training and hiring local residents. As of February, 2016, they have a weekly farmstand and provide leafy greens to three area grocery stores (www.aerofarms.com). The level of success of CEA farms like this should be closely monitored.

Practical Implementation of CEA

The cost to create a CEA farm is just as important as having the available space, and must be of net economic value to the city of implementation, or to the business owner, in addition to the potential environmental benefits. The Macrothink institute in Germany assesses the cost of constructing a new building for a 37 floor CEA farm, as well as the requirements for energy and water (Banerjee, 2014). The area taken up by this structure is 0.25 ha, and the yield was 3,500 tons of fruits and vegetables, which is 516 times more yield than an equal size of farmland. (Banerjee, 2014). The exceptional yield is possible because of stacking growing trays on the 37 floors, and year-round harvest. The purpose of the investigation, in addition to the higher yields, was to estimate the potential market for this type of farming; based on extensive market analysis the conclusion was that there is a current market for 50 of these types of farms in this area in Berlin, and a potential for 3,000 more in the future (Banerjee, 2014).

A feasibility study was conducted in Charelston, SC by Clemson University in regards to turning a vacant building into a CEA farm (Clemson, 2011). The city of Charelston, the EPA, and several other organizations were intricately involved for every step of the process. The main objectives were focused on the development of an initiative that is supported, organized and run by a diverse group of stakeholders; this method was used so that decisions made and risks involved were shouldered by many. Clemson University students studied CEA farming to understand the technical aspects and to give the stakeholders the best chance of having faith in the project. Their focus on community involvement was an attempt to show that A) a farm project is beneficial to the community; and B) that this level of diversified community involvement is necessary for success (Clemson, 2011).

There are two main ways of looking at the purpose and development of CEA farming. The Clemson study focuses on the community benefit of local food production, education, job creation, and a general sense of working together. Nonprofit organizations can receive funding for projects that are beneficial in this way, but a plan of development as in depth as the Clemson study is time consuming. Even this theoretical project had many obstacles and setbacks related to community involvement. Some similar initiatives in Detroit have been proposed and thoroughly vetted, but as yet have been unable to gain funding. It is not totally clear from the Clemson study whether their process for this specific project would be beneficial in a place like Detroit.

The other option for funding, though not mutually exclusive from the first, is that it is simply a profitable business and an individual makes the initial investment. The owners of Artesian Farms bought a vacant warehouse and invested in equipment and is expecting to see profits within 2 years, according to Jeff Adams, the owner. There are many new businesses in this industry over the past few years. A map designed by the Association for Vertical Farming shows hundreds worldwide, clustered mostly in the US, Europe and eastern Asia (Association for Vertical Farming, 2017). Some middle ground that involves individual small businesses with community development intentions may be the future of the industry. Green Collar farms in Detroit has a mission to create a technical model for a CEA farm that could be easily implemented by other locations, like franchises, to set up in low income communities, but are run by individuals who earn the profits. They partner with Detroit's Eastern Market, Florida A&M University, and Shaping Cloud, an innovative data storage and transfer company (from www.greencollarfoods.com). One great thing is that many people in this industry seem to prioritize community benefits, setting up near urban food deserts and hiring only a local labor force. Environmental justice and human justice are interconnected in so many ways and urban farming has great potential to be a key in this connection.

The Clemson researchers admit that the focus on community stakeholders was very difficult, from the initial recruitment, to getting everyone scheduled for meetings, to discovering whether, in the end, the team could actually pull off the project. Challenges emerged from working with the city as well, partly because of changes in personnel during the lengthy project. Their goal was not just to have a variety of stakeholders involved in the project, but to have them actually *design* the project collaboratively. This collaborative strategy may have been the key in the amount of difficulties faced, allowing so many people to be a part of the vision. It's possible that knowing the project was theoretical impacted the motivation for the project; however that is not in the control of the researchers.

The Clemson study is highly relevant and useful for anyone looking to do a similar project, as the team learned a lot about the challenges and advantages of such a high level of community involvement. One thing it seems they could have done differently is bringing in a team that already has knowledge on the process of designing and building, instead of using the process as an educational tool. Their work sets the bar for one extreme of how this movement towards indoor urban agriculture can be established. However because of the length of time and difficulties involved, and growing environmental pressure that makes this industry viable, I decided my direction was to view the CEA farm as a small business, and focus on potential private profitability as the driving force for growth in the industry.

Another assessment was done in Oakland, California on vacant land that could be used for agriculture to create or supplement local food systems. Although this evaluated soil-based agriculture, it is valuable information for an integrated agricultural model which may use soil-based farming as well as soil-free CEA farming. The study found enough useable vacant land to replace 7.3% of the supply of imported fresh produce to the city of Oakland (McClintock, 2013). With the innovations of CEA, it seems that much more of the food supply could be replaced because of the year-round harvests and stacked growing trays; in addition, there would be no need for soil testing if using a soil-free method.

Detroit as a Model for CEA Development

In 2010, some neighborhoods in Detroit were estimated to be 50% vacant, and there were approximately 75,000 vacant structures, including residential and commercial (Mogk, 2010). The cost to maintain these buildings is hefty, to the tune of $800,000 per year (2010), and so they are left to decay and bring down property value in surrounding neighborhoods. The depopulation rate of the city has caused high unemployment, and difficulty getting resources into low income neighborhoods. Consequently, many areas of the city struggle with access to healthy food, employment, and other basic necessities. The city already has a rich history in urban agriculture, and the ability of CEA farms to utilize vacant buildings, create jobs and provide fresh produce makes it an excellent potential model for vacant building conversion.

Urban farming in Detroit dates back to 1894 when an economic recession forced Mayor Hazen Pingree to create the "potato patch plan", which allowed residents to grow food on city lots. Starting with this example, urban agriculture was created from economic struggle. Racial conflict began in Detroit in the 1940s and the historic race riots of 1967 led to the first drop in population. Around this time, in the 1960s, is when urban agriculture started springing up in other cities across America (Ferguson, 2015). Although Detroit's economy and population revived due to the heyday of the automotive industry, urban farming has been used on and off through the years to feed the urban poor. Today there are approximately 2,000 farms in the city (Resnikoff, 2014), including small family gardens, and larger farms owned by individuals that sell to farmer's markets or by non-profit organizations that focus on community education and development.

Recently, city initiatives have been enacted to increase urban farming and to create a profitable business model for the industry. However, no initiative from the last few years seems to yet be successful on a large scale. Mayor Dave Bing proposed a new land-use plan in 2012 called Detroit Future City. Part of this initiative required residents to move so that a consolidated piece of vacant land of approximately 100 km could be developed by corporate agricultural companies. Residents were understandably resistant and there were other issues too, including one company wanting to plant 70 hectares of trees on the land, which wouldn't be of use to the struggling city for decades (Ferguson, 2015). The current Mayor, Mike Duggan, claims to be committed to these farming initiatives but no specific progress seems to have been made. Recovery Park is another ambitious initiative announced in 2014, to turn 22 blocks of the city into a $22 million urban farm. As of 2016 there were two CEA farms in the city that are for-profit businesses and privately owned.

The two CEA farms are Green Collar Foods and Artesian Farms; both are relatively small but successful operations that provide food to several local stores and restaurants. Both of these farms utilize local employment and plan to expand to sell to grocery stores around the city. Green Collar Foods is a nonprofit organization that uses CEA and aeroponic growing techniques and also trains local residents to become operators of their own aeroponic farms. If successful, this suggests that nonprofit and community involvement together advance farming techniques and can potentially create enough produce yield within the proposed integrated system as to be impactful in replacing some of the city's overall food imports. However, as a non-profit, they will need funding. Artesian Farms, alternatively, is a for-profit business run by an individual who is a long-time member of the community and hires only local labor. With the current technological advancements and the great need for revenue, both of these farms could be part of the rejuvenation of the city of Detroit.

Detroit has been praised for its wide use of urban gardening to combat food insecurity and build community by encouraging involvement. And although it is useful for individuals as well as tight-knit neighborhoods that truly aim to take care of each other, does it seem plausible to grow enough food on vacant lots to actually reduce the amount of food transported into the city and therefore reduce the emissions of those transports? In contrast, CEA may have the potential to actually increase local food production enough in cities to have a large-scale positive impact on agricultural practices. My ultimate goal is to assess the potential of CEA for sustainability based on environmental impact and practicality based on market demand for local food, and for eventual implementation of the proposed ideas.

Feasibility of Urban Farming in Detroit

As noted, there are two existing CEA farms in Detroit, and about 2,000 urban farms and community gardens. In addition, the surrounding areas and throughout the state, including Lansing, have urban gardening utilizing vacant lots to grow vegetables. There is a great application here of the urban farming movement that involves many community volunteers. This is a great use for vacant urban lots assuming the soil is tested and is safe. And even though a city like Detroit has lots of vacant lots, many cities wouldn't have those available, or if they did, they would eventually be repurposed for development, because this makes more money for the city. This may be why urban farming has been able to flourish in Detroit, but it doesn't mean it will solve larger food insecurity problems in highly population-dense cities like Manila and Mumbai. Does traditional urban farming have an important place in the future of agriculture? Should the city of the future have designated spaces for this, and will that ever be chosen over financially-beneficial development?

The Greening of Detroit is an example of a success story of one type of urban agriculture; one that is public and both publically and privately funded. It is credited with repurposing 135 acres of city land into 1410 gardens tended annually by around 20,000 people (Atkinson, 2012). There is little doubt that endeavors like this have helped to revitalize many cities, and the benefits are mostly for the community.

Detroit's urban agriculture is mostly funded by nonprofit grants and corporate funding, apart from the individual for-profit businesses, such as the CEA Artesian Farms. In 1996, a federal program was created called Community Food Projects Competitive Grants Program, which directly allowed the modern era of urban agriculture to grow. The city generally did not provide assistance or funds for these farms, because of their own financial depression, but what it did provide was vacant land, for the same reason. This in combination with the federal grants created a boom in the early 2000s (Pothukuchi, 2015). In 2013, an urban farming ordinance was created for Detroit to govern permits, definitions, and acceptable activities. The fact that "the implications of the ordinance… are unclear", in Pothukucki's words, is a testament to the concerns of the future of the industry. These concerns include whether the ordinance will benefit local people in the long run, how communities might be forced to change, and corporations taking advantage of the newly profitable industry (if it becomes one). Modeling a theoretical CEA project for the purposes of this research allows me to assemble the different factors from other farms in the region and create an example of the overall potential.

On multiple visits to Detroit, I encountered two different opinions about the future of the industry. The founder of Artesian Farms, Jeff Adams, claimed that his business was booming and after two years he would be ready to expand. He seemed very hopeful for future profitability. Frank Gublo, co- founder of Green Collar Farms, which has been open for about the same amount of time, essentially feels that no one will ever make money in this industry. It's a dichotomy of thinking that happens consistently in this new industry, perhaps because of varying backgrounds; CEA owners who were previously traditional farmers likely look differently at their business than those who are completely new to farming. It's also possible the difference of opinion lies in the fact that there just isn't yet adequate data from many experiences to back anything up, because the industry is so new.

Choosing Location for Detroit CEA

Part of the reason that Detroit is an ideal place to model this CEA farming experiment is because the cost to purchase a space is very low. However, part of the reason for that low cost is the extreme economic depression the city has been experiencing for decades, resulting in high unemployment and staggering crime rates.

The website www.homefacts.com is a resource for understanding neighborhoods and cities based on proximity to schools, environmental hazards, crime rates, and other factors. This website gives the city of Detroit an "F" rating for crime, a rate that is 6 times higher than the national average and a murder rate 9 times higher. For example a search for 7043 East Kirby Street, a vacant warehouse and potential farm location, the site indicates there are 95 registered offenders within a one mile radius of this property.

The location of the theoretical farm was chosen based on information obtained from two Detroit CEA farms, Artesian Farms and Green Collar Foods. I searched several real estate websites to find warehouses for sale, and looked for ones that were near to the size of the two existing farms, for ease of comparison. The space also needed to be reasonably priced, again compared to the existing farms, which is appropriate because this endeavor is likely to be taking place in a vacant and run-down warehouse space and the challenges associated with that should be explored.

It should be noted that the amount of abandoned school buildings and churches in Detroit is also extensive, and could be utilized for CEAs. Schools are slightly more complicated because they are typically owned by the city, and the interior space may not be ideal for CEA farming. A church building could provide the same simple, large space that a warehouse would, with the added benefit of a positive cultural history and proximity to a community, as opposed to an industrial district.

Proximity to a community that could benefit from the farm is highly desirable, as a major objective of this type of farming is for it to be a local source of fresh food. There are still factors to consider, such as how residents transport food to their homes and whether they will be given discounts on the food if they live within a certain proximity. The community can also benefit from job creation and a point of neighborhood pride. Although profitability is necessary for the sustainability of the business, discounts can be given to residents of the neighborhood, and employing locals provides improved economic stability to the community.

Table 2. Price and size of multiple farm locations.

Location	**Artesian Farms**	**Location 1**	**Location 2**	**Location 3**
Selling Price	$35,000	$9,900	$69,000	$75,000
Size (sq ft)	7,200	5,000	13,200	12,177

(Source: Jeff Adams; www.loopnet.com; www.realestateoodle.com; www.cityfeet.com).

Artesian Farms is 7200 square feet and was $35,000 to purchase, according to owner Jeff Adams. Keeping within a relatively comparable range to this was the guiding figure to finding the theoretical location. Websites used to find real estate include www.loopnet.com, www.realestateoodle.com, and www.cityfeet.com. The two main options were a 5,000 square foot warehouse for $9,900 and a 13,200 square foot warehouse for $69,000, which were both listed as available as of June 2016 (Table 2). It was preferable to have more space to work with, since part of the purpose of this is to estimate future growth potential. The location at 4800 Elmhurst Street seemed ideal with 13,200 square feet, but with the help of GoogleEarth to visualize the actual space, it turned out to be a one-story building. Though you could still do some stacking, the CEA aspect of this really needs high ceilings, or about a two story open space to get the most benefit. Another location was found for sale at $75,000 for 12,177 square feet, slightly more expensive and smaller than the one on Elmhurst, but it is a taller building and this will be better for the stack of trays on scaffoldings. This is northwest of downtown Detroit, at 7043 East Kirby Street. These three properties are acceptable for a potential CEA, based on cost, sizes, and GoogleEarth images (as visiting property was prohibitive).

Emissions and Environmental Assessment

An eventual goal of urban CEA, in addition to the benefits of a local food source for urban populations, is the reduction in carbon emissions as the status quo for transporting food into those cities. Of course the overall decision about how much to implement CEA is based on how effective and productive urban farms would be, if they were to be a food source that replaced some portion of the current supply. Urban farms can be effectively used to reduce emissions from traditional sources; the key factor is to choose produce for the urban farm that is most typically air-freighted, such as fresh fruits and vegetables that are out of season. These would have the highest carbon footprint, and could be specifically replaced (Kulak, 2014). Another option is to replace the products that are known to be the most carbon intensive in the production process, which would mean that the CEA farm must be able to grow those specific crops. In the northern US and Canada the foods that are most likely air-freighted (as opposed to shipped by boat) in the winter months are lettuce, tomatoes, asparagus, strawberries and cut flowers (Berners-Lee, 2011). Production and transport of food accounts for 9% of greenhouse gas emissions in the US, and globally agriculture is responsible for 30% of emissions (Thornton, 2012). As lettuce is often air-freighted, it is a good choice for CEAs and represents a promising possibility to have a real impact on reducing emissions. An LCA allows for a representation of all aspects of a product or service from beginning to end of life (Figure 4).

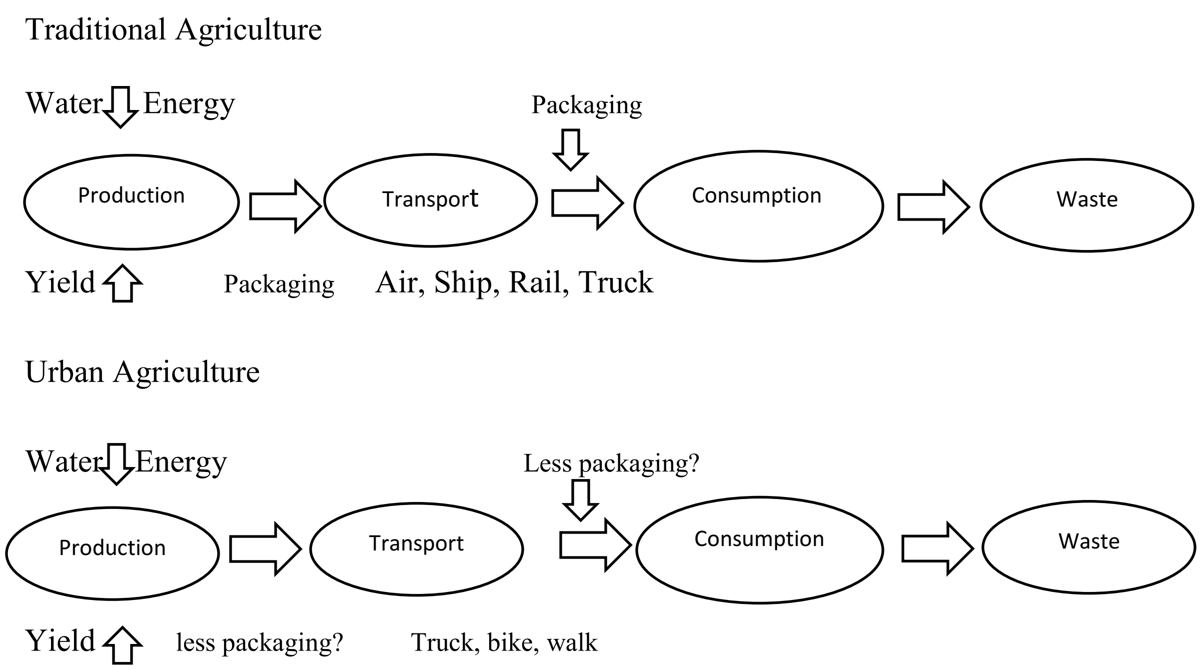

Figure 4. LCA flow diagram for traditional and urban agriculture.

Case Study: Traditional vs. Hydroponic Lettuce

A study published in 2015 in the International Journal of Environmental Research and Public Health compares lettuce grown on traditional fields with CEA hydroponic method, looking at the factors of yield, energy use and water use. The location was Yuma, Arizona, an area known as one of the largest producers of lettuce in the US, and the location turned out to be a very important factor in both the outdoor and indoor farming techniques. In traditional farming, factors of climate, weather, soil and rainfall are paramount to yields. But it is also relevant to indoor farming, as the amount of energy used for heating and cooling (the greatest energy use, according to the study), is directly dependent on the outdoor temperature.

First, the problem of water use is introduced: 38.6% of ice-free land (Sacks, 2014) and 70% of freshwater globally (WWAP, 2009) are used for agriculture. Also the argument is made that all kinds of produce can be grown by hydroponics, including tomatoes, cucumbers, peppers, eggplant, and strawberries. The data comes from government statistics of lettuce production in Yuma, and numbers from a theoretical indoor hydroponic lettuce production in the same location.

Table 3. Energy use, water use, and yield of traditional and hydroponic growing methods (Adapted from Barbosa, 2015).

Production Method	**Energy Use (kJ/kg/y)**	**Water Use (L/kg/y)**	**Yield (kg/m2/y)**
Traditional	1100	250	3.9
Hydroponic	90,000	20	41

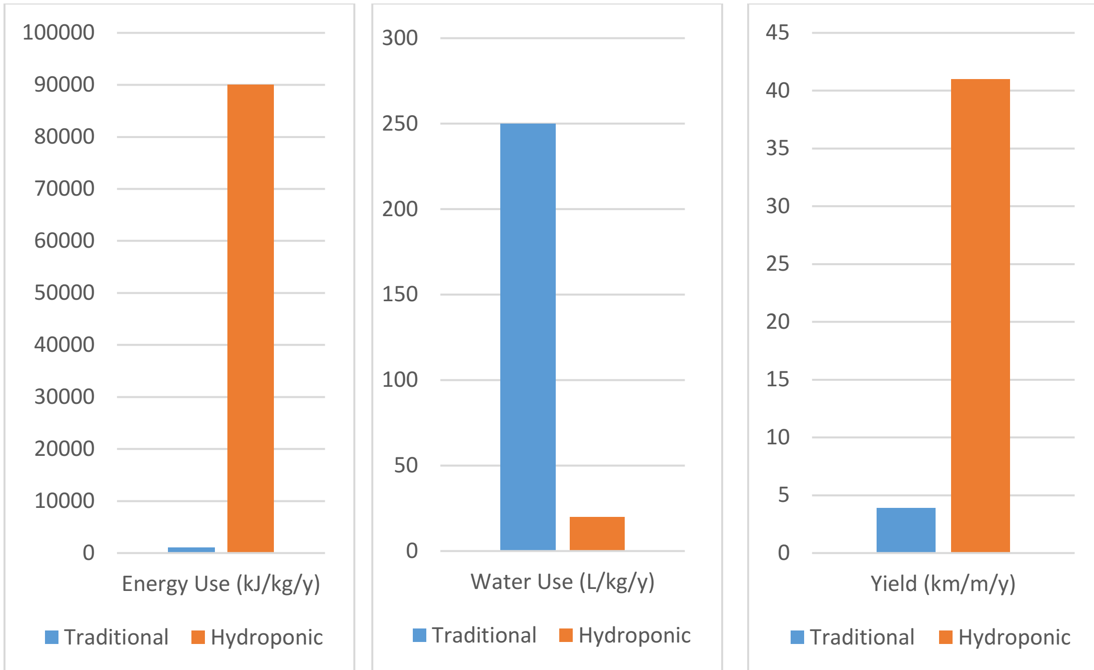

Figure 5. Energy use, water use and yield for tradition vs. hydroponic lettuce (Adapted from Barbosa, 2015).

Second, the study found that traditional lettuce produced 3.9 km/m/y and used 1,100 kJ/kg/y of energy and 250 L/kg/y of water; hydroponic lettuce in the same area produced 41 km/m/y and used 90,000 kJ/kg/y of energy and 20 L/kg/y of water (Barbosa) (not including standard deviation from the original study). These numbers can be compared in graph form (Table 3 and Figure 5). Essentially hydroponics has a higher yield and uses less water, but uses a lot more energy: 82 times more energy, to be precise, as well as 11 times higher yield and 12.5 times less water. The difference in the use of energy is, of course, because the sun is the energy source for traditional farming. Indoor farms can boast that they are climate controlled and therefore can have year-round yields and avoid issues related to weather, but they need an energy source. The biggest use of energy was controlling temperature, and other uses included artificial lighting and water pumps. The study assumed the use of nutrient film technique, which pumps water through channels under the plants. The research done in Yuma addresses a critical point as to whether farming indoors with manufactured sunlight is advisable, when traditional farming uses our best renewable resource: the sun.

A different way to look the numbers from the Barbosa study uses inputs and outputs of the LCA method (Figure 6). The study only looks at production, so a more extensive understanding of the system would require data on transport, distribution, consumption and waste.

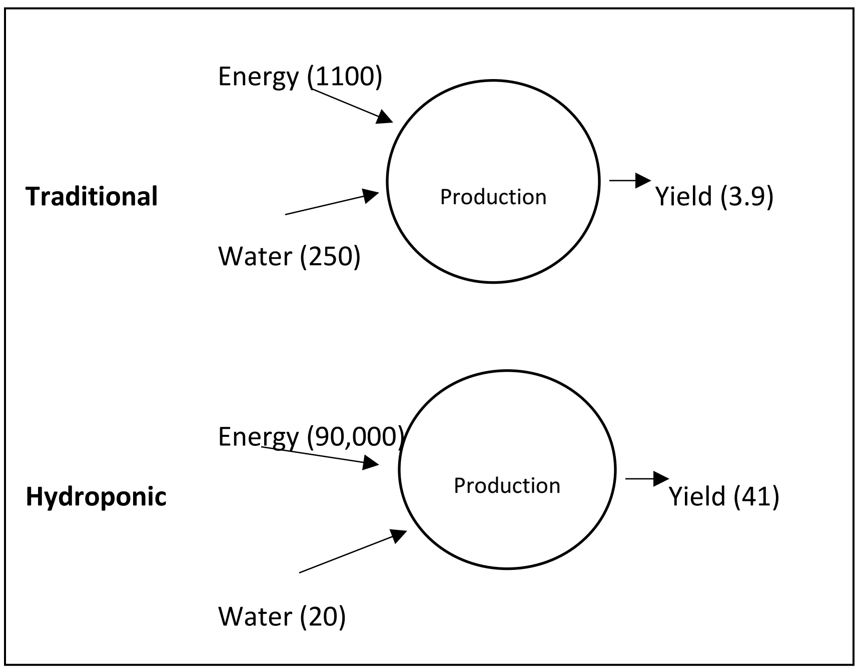

Figure 6. LCA diagram of production phases of traditional and hydroponic agriculture (Barbosa, 2015).

The conclusion of the study was that hydroponic lettuce is not suitable for Yuma, Arizona, since so much energy is needed to keep the building cool in the hot climate. However, the authors quickly suggest that it does not discount use of this technology in a more appropriate climate. They point out that energy use will vary by location since temperature control was the biggest factor: "Greenhouses located in more moderate climates (ie., climates closer to the greenhouse set point temperature) will experience a lower energy demand" (Barbosa, 2015). In deciding farming methods for certain areas, availability of renewable energy should be assessed, to see if it can be used to reduce the energy impact. Reduction of energy is discussed in the use of lighting, as this study assumed maximum yield. Furthermore, use of solar energy and other renewable sources can completely change the energy uses of these indoor farms. This, of course, can also be argued with traditional farming. If traditional agricultural production was more sustainable, it wouldn't be necessary to construct and study an industry of indoor farming. However, this researcher admits the difficulty of making change in the considerably powerful system of industrial agriculture, and seeks to create options for consumers to make choices that might weaken the status quo.

Increasing populations and scarcity of resources could increase the consumer trends towards sustainable local food sources; the number of farmers markets increased by 180% from 2006 to 2015 and regional food sales increased by 288% (Low, 2015). These may still not be huge numbers, but it indicates a potential behavioral shift in Americans towards sustainably grown produce, could have the power to change the market.

Finally, the Barbosa study of traditional lettuce production versus hydroponic asserts the differences in water, energy and yield as demonstrated in Table 5 and Figure 5. This is for a single-level hydroponic farm, using LED lights to simulate sunlight (2015). The energy use is far higher with the hydroponic method, arguably enough higher so that the higher yield will not be beneficial enough. However, further analysis reveals that the breakdown of the energy use is far higher for heating and cooling (74,000 kJ/kg/y) than for artificial lighting (15,000 kJ/kg/y) or water circulation pumps (640 kJ/kg/y) (2015).

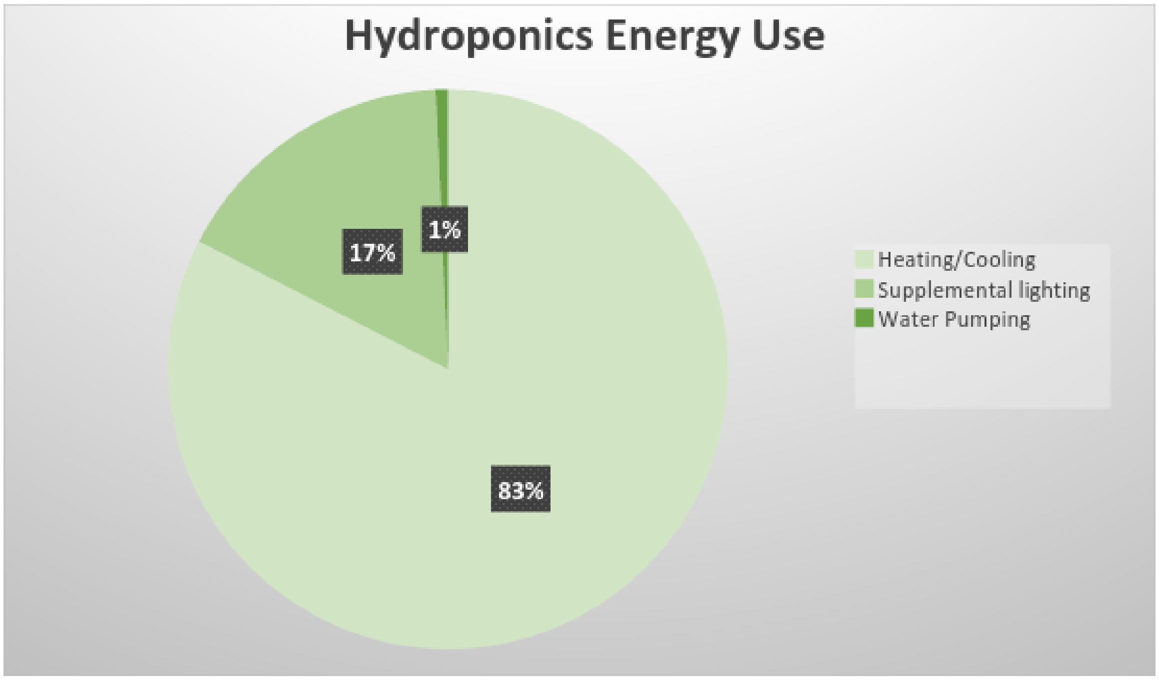

Figure 7. Energy uses breakdown for hydroponic growing (Adapted from Barbosa, 2015).

Since the study assessed a single level of crop production, CEA farming could be used to increase yield without an equal increase in the amount of energy used. If artificial lighting was the largest energy use, it would stand to increase as much as the yield increases with the stacking of growing trays that would all need lighting. But since heating and cooling is the biggest use, it would not increase with the addition of growing trays. The lighting use would still increase but overall the energy use to yield ratio would be more sustainable. This could be the key to one way that CEA can be more energy efficient.

Assessment of Local Food Trends

As previously mentioned, the 'What's Hot Culinary Forecast' reported the top food trend of 2017 to be hyper-local sourcing. Another major trend was concept-based food rather than ingredient based (National Restaurant Association). Which could mean that restaurant-goers are more willing to eat based on a concept such as sustainability or locally-sourced, rather than caring about specific ingredients. A major behavior change that is required to improve the environmental impact of our food system is for people to accept that they may not be able to buy any food they want at any time of year. Of course, the 'What's Hot Culinary Forecast' is predicting trends that could end up being more like fads, and have no staying power.

The popularity of direct-to-consumer (DTC) channels such as farmer's markets and CSAs has been extensively studied (USDA, 2016). Intermediary marketing channels such as regional distributors to grocery stores and restaurants are discussed but not measured. From 2002-2007 DTC the amount of farms increased by 17% and DTC sales increased 32%. Then from 2007-2012 DTC farms increased 5.5% and there was no change in DTC sales (Low, 2015). The slowing increase and lack of change could be due to sales by intermediary channels increasing, which is still considered local. The USDA report claims that these intermediary channels are not measured and therefore accurate measurements of sale of local food is challenging. The researcher recognize the importance of local food and its growing support, but admit to a lack of sufficient data. The 2014 Farm Bill calls for the USDA to "collect data on local food production and marketing, to facilitate data sharing, and to monitor the effectiveness of programs designed to promote local food systems" (Low, 2015).

Collecting data is challenging because many intermediaries are beginning to emerge to take advantage of the consumer demand. Even Walmart boasts local produce, and promised to double their stock between 2013 and 2015 (CNBC, 2013). Despite large grocery store chains offering local food (or perhaps because of it), large, CA growers/distributors lost 15% in sales in 2012 (Rabobank). Farms selling DTC were more likely to stay in business between 2007 and 2012 (Low). The amount of farmers markets in the US has increased from 1,755 in 1994 to 8,669 in 2016. However, the rate of increase has remained fairly steady, with a 2.3% increase from 2015 to 2016.

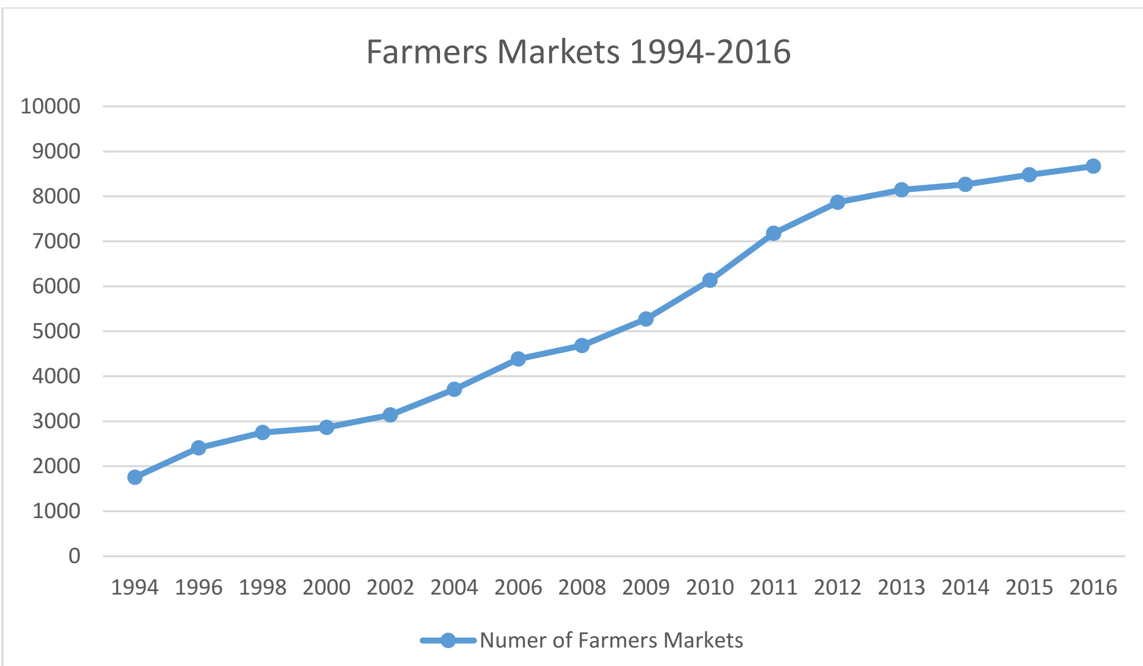

Figure 8. Number of farmers markets 1994- 2016 (Adapted from USDA AMS Local Food and Research Development Division).

The true economic benefit of local food is difficult to measure because standardized data is not collected and there is little agreement among researchers on how to measure. But there is some agreement on the potential benefits of an increase in locally sourced food, such as boosting rural economies, increasing low-income access to fresh food, sustainability of the food system and strengthening local markets (Low, 2015).

Challenges Faced by Small/Local Farms

Though there are few numbers to analyze in such a new industry, it stands to reason that CEA would face similar challenges to small rural farms, with a few exceptions. Typical challenges of small traditional farms include weather and pests, two unpredictable factors that contribute to the overall success of any season. Organic farms have the most risk of damage from insects, but even conventional farms using chemical pesticides or integrated pest management can lose crops due to the presence of unexpected insects or resistance to pesticides. Droughts can create an economic hardship if extra irrigation is necessary, or entire crop loss if irrigation is not possible. Farms that use chemical pesticides and excessive irrigation are the most likely to succeed, but are also the most detrimental to the environment as they create runoff that pollutes local water systems and use too much freshwater.

Financial challenges that face small farms include a maximum profit amount that is based on the maximum that is able to be grown; this is theoretically also true for large farms, but large farms often receive government subsidies, allowing them to be more competitive than smaller farms. Costs to run a farm can be prohibitive and not allow for expansion, which often means no upward financial growth is possible. Some farms that produce more can actually lower production costs as they also raise profits (economies of scale), but this is not possible for many smaller farms.

In addition to limited potential for growth, small farms also have less guarantee of profits than large farms because of marketing and distribution strategies that are more difficult to access. Larger, consolidated farms have contacts with larger distributors and support from powerful corporations; farms can be comfortable in fulfilling their contracts and can build up extra profits to accommodate seasons affected by unpredictable circumstances. Smaller farms must work harder to find places to sell their produce, not having access to the same supply chains (Hazell, 2006).

Ideally CEA farms might help to shift the food system away from corporate, industrial large-scale agriculture. The idea that large-scale agriculture is the only way to feed the world's growing population is held up by trade agreements that allow food from this industry to be sent all over the world. It de-incentivizes food being dispersed locally and makes it more difficult for small farms to compete (Rosset, 1999). But if the economy truly were designed around sustainable agriculture, selling locally would be just as viable. Small farms are in fact very important to the economy, as "decentralized land ownership produces more equitable economic opportunities for people in rural areas" (Rosset, 1999), as well as it benefitting local economies in many rural areas around the country.

NYU economist Carolyn Dimitri points out the fact that small rural farms and urban farms face similar problems, in the expense of labor and the competitive pricing of food (Royte, 2015). Brooklyn Grange, a rooftop farm in New York City must supplement their farm profits with tours of their facility and renting the space for events. Another NYC farmer partnered with a farm in upstate New York when she realized she needed to diversify the available vegetables to increase sales (Royte, 2015). These are both for-profit farms, so of course they need to ensure they can sustain their business. Non-profit farms generally get by because they are able to use volunteer labor because they benefit the community, and funding is available because they are providing a service to the community in the form of local fresh food, farming education and community pride.

As previously mentioned, urban agriculture is not remotely a new industry. Neither is it by any means a small one. In sub-saharan Africa, where 70% of people experience food insecurity, and the population is predicted to double in the next two decades, 40% of people in cities are growing their own food (Reed, 2014). Urban farming has mostly developed out of necessity. Worldwide, it is estimated that 800 million people are involved in urban agriculture (FAO, 2016). In addition, these farms and gardens around the world actually produce a lot. Community gardens in Detroit produced 400,000 pounds of fresh produce; around the country, cities boast similarly high amounts, one of the most being Philadelphia's two million pounds of vegetables and herbs in the summer of 2008 (Royte, 2015). These farms provide local produce to low-income neighborhoods as well as to the increasingly discerning grocery shopper, looking for local and knowable food sources, even at major grocery store chains. Organic farmer Dave Chapman claims in a newspaper article that hydroponic produce was edging out his produce in the local grocery store (Nanos, 2016). Though hydroponics/CEA are a very small part of the market, these hugely productive urban farms and gardens have paved the way for a new version of this industry that builds off that success but with the goal of tapping into the larger markets of grocery stores, especially if they are producing local fresh food year round.

Table 4. Examples of urban agriculture production (non-CEA) (Royte, 2015).

City	Pounds of Produce	Year
Philadelphia	2 Million	2008
Detroit, MI	400,000	2014
Brooklyn, NY	40,000	2014
Camden, NJ	31,000	2014

The big question is whether the trend of urban farming is it just a trend—or if it can actually change the food system. The same question is relevant to the demand for local food and whether that will continue to support urban agriculture. The small farming operations likely need economies of scale in order to expand and become a true industry that could change global agriculture. Farmed Here, a CEA in Chicago, grows a million pounds of produce and supplies 50 Whole Foods markets year-round. Their master grower says they can't keep up with the demand (Royte)—a promising statement from the largest CEA in the country. The demand for local food seems to be everywhere, from restaurants and grocery stores to schools and hospitals. 4 in 10 school districts in the US purchase local fruits and vegetables for their students (Low, 2015). But why would CEA farms be able to tap into these markets when for decades urban community farms have stayed at a small scale? It may be that the market is only now ready for this, as people are learning more where their food comes from and more about the downsides of traditional farming. But it is clear that this is the way to compete with big agriculture: tapping into the same markets. Boosting resiliency of urban food systems likely entails selling to local institutions as well as individuals (Royte, 2015).

But since so much urban farming is already happening, what is really the benefit of moving to CEA? Since they don't compete for the same spaces, it wouldn't take away the ability of community farms to continue to exist, unless they were competitive for the same markets. But this is where traditional urban agriculture reaches the ceiling; expanding facilities to be competitive and form economies of scale requires more land, labor, and likely permits. CEA would face the same challenges, except for the fact that they can build *up*, and grow year-round. This is the key to whether to incorporate CEA: Does the higher yield of indoor, year-round growth outweigh the higher energy use? Or should renewable energy be a CEA requirement?

Consolidation creates a more secure industry, more guaranteed profits and lower production costs. But is also means fewer businesses and people involved overall, and control is managed by fewer, larger corporations. But it can also mean more environmental impacts as growing methods are streamlined, such as biodiversity loss and creation of monocultures. It also starts to create a monopoly in the industry, and puts smaller farms out of business. And if these larger and larger farms are where most food is coming from instead of many smaller ones, there will be no local food choices for people in urban areas, and high CO2 levels created from food miles will continue to rise.

Accessibility of Small Farms to Markets

In late August of 2016 I walked into a Meijer grocery store in Lansing, MI, looking for tomatoes. I had been volunteering at Urbandale Farm, and as their crop had suddenly ripened, they had an abundance of perfect tomatoes. However, it was pouring rain all day so their weekly farm stand wasn't open, and I was tasked to bring a tomato mozzarella salad to a potluck. Thus I find myself at Meijer. The tomato section is large, and there are lots of shapes and sizes, so I start picking through, only to discover that the majority of the tomatoes here are from Mexico or Canada. Sunset farms, in fact, are where most of them are from, with a label saying "product of Mexico". Ontario is at least the closest part of Canada to Michigan, but I just couldn't believe that in a place where tomatoes grow abundantly, and in the season where they are exactly ripe, and there are far too many of them at an urban farm right down the street, there is not a single local tomato in this store. It seemed like a waste of easy resources.

The NRDC published a report in 2007 on food miles and specifically analyzed the impact of importing food to California instead of growing it locally. They found that the six foods most likely to be imported into California (grapes, oranges, wine, rice, garlic and tomatoes) are all also grown in California—and exported elsewhere! The result is a doubling of pollution from having those products both exported and imported. Part of the reason for this is the consumer expectation that all produce is available all year-round. That expectation is so prevalent that former regional produce director for A&P supermarkets Ron Pelger claims that in that store, cranberries are the only product he knows of that has an "interval"; a period of time during the year when it is not available (modernfarmer.com). Everything else is available all year.

Expecting the produce to be available all year is heavily engrained and would require a general change in behavior to stop that expectation, which of course is difficult. But in the example of Michigan tomatoes, it was in fact tomato season in Michigan, and yet the tomatoes at Meijer were still brought in from Mexico. So this is more likely an issue of distribution. Large grocery store, large distributors, and large farms are comfortably dug in together and have confidence in their system: the farm knows the distributor will buy a certain amount and the distributor knows that the farm will produce a certain amount. Essentially the only unknown factor that could cause both parties to lose money, is unpredictable weather conditions affecting crop growth, which, of course, could increase due to climate change.

Smaller, local farms do not usually have access to these contracts, possibly because large distributors do not trust the consistency of the product or how much of it will be grown, since smaller farms may have fewer safeguards against droughts and other weather conditions. This could be the way for CEA to get its foot in the door; Since this produce is grown in a controlled environment, it is not subject to environmental variables and the distributor could be assured of the amount and quality of the produce; although this would have to be assessed over time, as there may be factors that limit consistency that have not yet been studied.

Some CEA and small urban farms do provide to grocery stores (Artesian Farms, for example), but they are typically smaller, regional or local stores. Large distributors need a guarantee of a particular type of crop, whereas smaller, independent stores have more flexibility to accept what is freshest at any particular time, and probably tastes best, but the customer has to be more willing to buy what is available. Small farms have difficulty gaining distribution contracts with grocery stores, if they can't guarantee a certain amount of produce like larger farms can.

Darren Riley of Green Collar Foods described one attempt to match small farms up with large stores/distributors through an online platforms; however this was not successful. He theorized that the right time for this merger to explode into the industry of food production hasn't quite arrived yet, because not enough people trust the technology. The industry may face challenges with marketing, especially when it is so new that consumers may not understand or be able to imagine their food being grown indoors, and therefore not trust it.

Carolyn Dimitri of NYU doesn't think CEA farms will be able to be competitive in the industry with traditional rural farms, claiming they are unable to use resources efficiently and therefore economically unviable (Royte, 2015). This is the essential question that a place like Farmed Here may be able to answer, based on its success or failure in taking the next step into marketability. Dimitri's assertion is based on the current state of the market, which, based on consumer demand, can change, albeit slowly. This brings into play the idea of a change in human behavior; if, for example, a person goes into a grocery store expecting to find local, in season produce, as opposed to assuming they can get anything from anywhere in the world at any time of year, the market could change as well in a way that allows for larger-scale urban farming.

Assessment of Organic and Local Produce

Sales of organic produce went up 72% from 2008 to 2014, with total sales at $5.5 billion (USDA, 2015). The most promising aspect of this is that it seems to be millennials (age 18-34) who are mostly driving the market in demanding food that is healthier and better for the environment (OTA, 2016). Organic, local, pesticide-free, antibiotic-free, are all factors that many consumers are now demanding in their food sources. A recent article on forbes.com points out that the current food industry is not set up to be able to provide this and will face major strains in the future in trying to keep up with consumer demand that differs from what they have the current capacity to offer. The food system is set up for the popularity of and reliance on processed foods high in sugar and fats and traditionally grown produce; however, it is important to recognize that the modern agriculture system ensures there are fewer people worldwide who suffer from malnutrition and food insecurity. The food supply is more consistent and reaches farther. Now it just needs to be more sustainable.

Agriculture itself changed the natural land when humans first implemented the practice. Humans modified their environment to fit their needs as our ancestors moved on from hunting and gathering to farming (Despommier, 2011). Of course, arguing that agriculture itself is unnatural and therefore any practices within that practice should be allowed, is not particularly helpful. The important point to remember is that agriculture was designed to feed humanity is a streamlined way, and that is still its major purpose. So if the most streamlined way to feed humanity must adapt and change with the growing population and the realization that agriculture is not necessarily good for the land, then change must come. It may be that organic farming is the best way to ensure a sustainable future, but surely supplementing with CEA farming is better than supplementing with conventional farming.

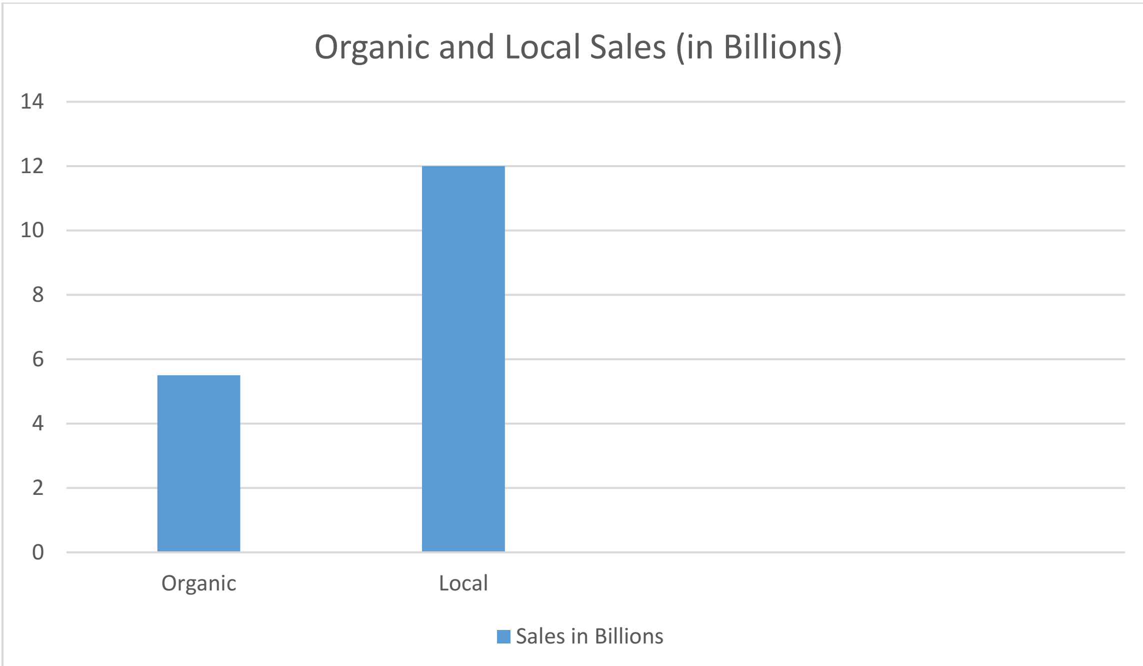

Figure 9. Sales (in billions) of organic and local produce in 2014 (USDA, 2015; USDA, 2016).

The USDA estimates that the sale of local foods, currently at $12 billion, could top $20 billion by 2020 (USDA 2016), while the sale of organic food is considerably less at $5.5 billion (USDA 2015) (Figure 9). The USDA touts the importance of this for rural communities in creating jobs and revitalizing farms; of course, because this is where the farms are. But if the local food system is adhered to everywhere, than urban farming doesn't take jobs or business away from rural farmers.

Internship at Urbandale Farm

As a means to get involved with the urban farming community in Michigan, I volunteered at an urban farm in Lansing through the summer and fall of 2016. This was not an indoor farm, but many of the principles of urban agriculture are similar, and an integrated, sustainable system requires all methods. There was not an option to volunteer at the CEA farms in Detroit, because they did not currently require the extra help.

Urbandale farm is in an area of Lansing that is a flood plain, so no further development is zoned and there were several vacant lots when the farm was established. The farm is on five lots integrated with residential houses, and one large hoophouse. It is also an economically depressed area and is considered a food desert. Neighborhood residents receive a discount at a weekly farm stand on the property of the farm.

The farm produces a variety of vegetables (as well as flowers), brings produce to a weekly farmers market as well as provides to a CSA and takes special orders from stores. There is a farm manager as well as three apprentices throughout the season, who tend to two acres of land. This was an educational and invigorating experience in all aspects and made clear the various challenges and benefits of this type of traditional urban farming vs indoor CEA farming.

Significant obstacles exist for both urban traditional and CEA farms related to marketing and distribution. Urbandale Farm sets up its own weekly farm stand, as well as selling at a local farmer's market, and occasionally gets orders from a local CSA (Community Supported Agriculture). However, there were times when there was more produce than avenues to sell it, and some was wasted; the exact amount of wasted produce was

Figure 10. Urbandale Farm, Lansing, MI (Photo by author).

not available. I inquired as to whether there were avenues to get this food to local grocery stores or food pantries, it didn't seem like there was any simple way to do that. It is difficult for a small farm to estimate exactly how much they will harvest and when, which is why it's challenging to establish and maintain distribution relationships that would keep the profits steady and the business sustainable. The CEA may have more luck with accurately predicting harvests, since they don't have to worry about weather.

The many small farms in Detroit face various challenges, depending on their size and what their intentions are. Farms like Urbandale that rely on selling at farmer's markets need to keep up with demand, perform all growing maintenance, harvesting on time, and avoid wasting crops. This is in addition to balancing labor costs. Community farms that provide fresh food to a few families or a neighborhood may be able to employ volunteer labor as well as donations, but if people are relying on this food, it needs to be carefully tended to. Commercial farms face various challenges, some of which also affect CEA farms, and some that don't.

Weather is another big challenge for outdoor growing. Farms will spend more money irrigating during a very dry growing season, as happened with Urbandale. The summer of 2016 in central Michigan was very dry, and Urbandale set up drip irrigation in nearly all of their fields. The June and July water bills totaled about $650 when a normal water bill for them is about that amount for the whole year, according to farm manager Caitlin Schneider. It also created more labor costs because of setting up the drip irrigation and monitoring it. Droughts, floods, high winds and other extreme weather can effect crop success and in turn the farm's profitability. Insects and other pests can also greatly effect a farm's success, and changing habitats of insects due to climate change could add additional challenges, especially for organic farms attempting to use non-chemical pesticides. An indoor farm avoids these pests and extreme weather conditions; however, an indoor farm cannot take advantage of the basic natural elements used to grow crops: sunlight and rain. So CEA farms must manufacture these elements.

Consumer Trends and Behavior Change

The metabolic rift refers to a theoretical framework bridging political economy, urban geography, agroecology and public health (McClintock, 2010), and it helps to understand the recent upswing of urban agriculture from an economic perspective. The rift can be viewed in a social context, stemming from overall consumption of land and food, or an individual context, when assessing humans' growing lack of connection with nature (McClintock, 2010). The rift is essentially all that is behind the curtain of manufacturing, food production, and product distribution, waste treatment, and any other processes in the modern world that are hidden from the consumer. These hidden processes create a rift in basic understanding of what these modern processes do to the natural environment and allows for a disconnect with nature that many people may not even believe exists in themselves. But if people ask themselves the question of "where does my food come from", "where do my clothes come from", or "where does my trash go", it becomes clear that degradation of the environment is happening, and is *hidden*, all around us.

Marx suggested there is a rift caused by capitalism that does not allow people to appreciate the natural environment and thereby leave it to be slowly degraded. But the reality is that capitalism *is* what drives the economy (US and to a large extent globally) and therefore environmental preservation and sustainability must exist within that framework. The good news is that consumers, ie, citizens like you and me, have some say in what products are made, by deciding what to buy. This control is somewhat limited in that they only get to choose from what is available, but successful products are successful because people bought them, and items that are never bought will be discontinued. It is a small way to vote for what matters to you; in the case of local/sustainable food, it could be a few rocks that lead to a landslide of changing customer demand that leads to a change in food production. The most significant example would be if every consumer stopped buying traditionally grown produce and instead bought only local, in-season and organic. Traditional agriculture would either go out of business or, of course much more likely, would adapt to fit that parameters of consumer demand.

This connection to the social and individual aspects of the food industry is valuable because of the behavioral change that is needed for systemic economic change. It's possible that if people were more aware of manufacturing processes and food production the disconnect could disappear and our consumer-driven economy would be based on what is reasonably able to preserve the natural environment. Of course a large-scale behavioral change requires a lot more than just a little extra information; but there is some evidence that consumers are paying more attention in order to eat healthier. The 2014 FDA Health and Diet Survey reports that 77% of adults surveyed read the Nutrition Facts label "always, most of the time, or sometimes" and 79% reported they read the label of a product the first time they buy it. Two-thirds of adults reported concern over their salt intake, and almost a unanimous amount agreed that the US population eats more salt than it should (Lin, 2016). In addition, 9 in 10 adults said they were likely to buy products that list "low in sodium", "low in sugar", or "rich in antioxidants", but only one-third of those surveyed thought those words were an accurate description of the product (Lin, 2016).

A major question is how to change consumer demand, when so many people buy what they know is not good for them, or know is not accurately described? What causes a person to choose to buy what is healthy, or what is better for the environment, or both? How to sway consumers to buy what is locally in season, as opposed to what they are so used to as an American—being able to buy any type of produce from anywhere in the world at any time of year? The reasoning behind consumer decisions may be variable depending on what the consumer cares about. The main reasons for change include: health, environmental preservation, support of small business, and animal rights. The rate at which these factors are altering consumer behavior can illuminate what forces have the most powerful potential for large-scale change in the market. A change in behavior could also come from policy that requires more specific food labeling, or requires new environmental regulations on agriculture.

The millennial generation is at the forefront of consumers who care where their food comes from and how it is prepared, and millennial parents are the largest group of highly discerning customers (Paul, 2016). In addition, 75% of natural food stores claim their customers care most about locally-sourced food (Paul, 2016). To the consumer, buying local food could speak to either sustainability or health concerns; though no evidence exists that local food is healthier, it is possible the consumer feels that local food is more knowable, and therefore the source more trustworthy.

Sustainability of Local Food Systems

The problem with thinking that local food is inherently healthier or more sustainable is that it assumes the transport method has the largest environmental impact, and if that is taken out of the equation, the food is inherently more sustainable. In addition, seeing a "local" label at a grocery store does not account for the nuances in the food system: that local item could have been brought 100 miles by truck, which could create more emissions than a product considered non-local that is transported by rail or ship. As previously stated, the transport method only accounts for 11% of agricultural emissions, whereas production accounts for 85% (Weber & Matthews, 2008). A label of locally grown does not actually say anything about the production method, (unless it also says organic), and could be grown using chemical pesticides, excessive water and toxic pollutants. If it is a meat product, the local label does not mean the farms doesn't use growth hormones, treat with antibiotics and treat the animals unethically.

It is possible that some people buying local actually are familiar with the farms their food is coming from, and in this case they would know whether the farming practices are in line with their own beliefs in what the food system should look like. However, there are limited studies on what the actual benefits are of a local food system (Rothwell, 2015). The environmental impact of tomatoes (canned, diced or paste) grown in California and shipped to the Great Lakes region was assessed and compared to tomatoes grown and consumed in the Great Lakes region. The result was that tomatoes grown and processed in each location had very little difference in greenhouse gas emissions (Brodt, 2013). Specifically, California uses more water but produces more per hectare, which they considered to offset CO_2 from the transport emissions, which was by rail (Brodt, 2013). This is an example of the importance of location and type of transport in assessing sustainability of local vs. non-local food production.

In Vancouver, British Columbia, the potential of 'agriburbia' was assessed, as a place to combine commercial and educational/community-oriented agricultural activities within a city (Newman, 2015). The study theorizes this could be a key to the development of sustainable food systems, because of the high potential of suburban food production. If a suburban area can also produce food, it could mean allowing land allocated to farming to return to its natural state and be protected. This could be crucial as urban development moves steadily across the country. The agriburbia concept is meant to utilize large and small commercial agriculture as well as local food movements in an attempt to find a balance of food resiliency for future urban populations (Newman, 2015).

Problems with CEA Farming

There are of course skeptics of CEA farming, and with some good reason. The Barbosa study concluded that, at least in a place like Arizona, CEA was probably too energy inefficient as compared to traditional, because the local climate made it necessary for a large amount of cooling in the climate control (Newman, 2015). This does not negate the validity of CEA in other places, but it requires more rigorous studies for the energy footprint in different climate areas, and extensive overall planning for where theses farms should or should not be allowed to be built. For example, a CEA farm in Arizona should use solar energy because of the intensity of the sun there. In Lansing, MI, where the weather phenomenon known as the 'lake effect' causes many cloudy days, alternative energy like wind turbines or a biodigester could be used.

CEA farming could be too energy intensive to survive on solar or wind power (year round) in certain climates (Royte 2016). Without the possibility of year-round renewable energy, these farms that use electricity generate much more emissions at the nearby power plant than, for, example a greenhouse. The solution to the higher energy footprint is easily to use renewables; this in fact would work in Arizona, but not in other places where solar energy is not strong enough in the winter months. So the previously suggested regulations on where to build CEA would be completely flipped if they were all using solar energy. There would need to be a complex plan in place for locations, based on what they were powered by: electricity, solar, wind, biodigester, etc.

In September 2016, a bill called the Urban Agriculture Act was introduced by Michigan Senator Debbie Stabenow, being praised as "the most comprehensive proposal of its kind for urban agriculture". The bill called for an expansion of federal financial assistance, research and risk management tools, education and mentorship for urban farmers, as well as a new urban agriculture office within the U.S. Department of Agriculture (Helms, 2016). The importance of this bill rests with freeing up federal aid for urban farms the same way it is given to large corporate farms; though it does not directly address CEA farms, they could also benefit if they prove beneficial to communities. It would benefit both community, non-profit farms as well as farms that are private businesses. This is not the first bill regarding urban agriculture in this country, but it is the most comprehensive, and it would be the first to be a part of the federal Farm Bill- to be signed in 2018. It seems appropriate that Michigan is on the forefront of changing industry, since community farms have had such a direct benefit in the lives of many low income people.

It seems less likely now that Stabenow's bill will pass, given the policies of the current Trump administration; however, it paves the way for more legislation in this area and creates a thoughtful dialogue on the potential future of agricultural subsidies. Beyond federal, it could stimulate the state of Michigan and the city of Detroit to offer more grants and subsidies to urban farmers.

This bill is promising because although the city of Detroit has some grants available from the city for community gardening efforts, especially for nonprofit farming organizations, the same funding does not yet seem to be available for CEA; even though trends for the desire for local food could change that in some cities. It could be that there is so much urban farming already happening, that small-scale CEA is less likely to have city funding in this particular city because they are competing with outdoor farms. CEA would have the environmental benefits, but the community benefits are already being felt from current farming practices.

Research Questions, Hypotheses and Specific Aims

The main questions of this research are: Can CEA farms be more sustainable than traditional farming (based on energy use and yield comparisons)? Is local food actually more sustainable than business-as-usual methods of production and shipping?

The primary hypotheses are:

1. Vacant buildings in Detroit can be converted into CEA farms that can be profitable businesses within 2-5 years, and provide community benefits.
2. CEA farms are a sustainable way to produce locally-grown vegetables in urban areas, based on energy use, and yield comparisons with traditional farming, and Urban CEA can mitigate agricultural emissions if it is used to replace a certain amount of industrial agricultural practices.
3. Increasing demand for local food is a market trend that is steady enough to support an increase in CEA farms.

To address these hypotheses, I needed to:

1. Quantify the sustainability of a CEA farm by assessing water use, energy use and yield.
2. Assess market trends towards demand for local food, and the economic challenges facing small farms.

3. Define an impactful amount of food grown by urban CEA that could reduce overall emissions from business-as-usual food production and transport, and recommend renewable energy sources based on location of farm.
4. Quantify the cost and feasibility of implementing a CEA farm in a vacant building in Detroit, including considerations for the surrounding community.

Chapter II

Methods

My goals were to (1) complete a feasibility study of converting a building into an urban farm; (2) perform an economic analysis of CEA and local food systems; (3) quantify environmental impact of CEA and local food systems. These were the main analyses required to address these goals and asses the research hypotheses.

Research Design

First key stakeholders were interviewed, such as the owners of the two CEA farms in Detroit to document the current approaches to opening an urban farm. These interviews allowed me to estimate initial investment and maintenance costs. I also gathered data on current yields of these two Detroit CEA farms. City zoning regulations and policies on vacant areas were consulted. I also contacted farms in other cities for additional data to help estimate cost. Once basic costs, yields and energy use were established, I estimated food transport emissions and goals that can be reached by urban agriculture to ameliorate a certain amount of food imports.

Detroit Analysis

I investigated the cost of buying a building from the city, by contacting farm owners, and researching zoning regulations. This required information on allowable uses of land and buildings, including whether a business can be implemented and possibly, whether small livestock is allowed, such as chickens. I used internet maps to find an ideal location. This needed to be close to neighborhoods that would benefit from access to fresh produce and creation of jobs. Projections of future profits from selling of produce were estimated, as well as projected community benefits. I met with the owners of two CEA farms for data on cost, future profitability and expected yield based on size of farm building.

CEA Sustainability

Data were compared on the environmental impact of CEA farming with a traditional food supply chain, using data from functioning CEA farms in Detroit, as well as studies regarding differences in energy use, water use and yields. Data collected on energy use and yield was used to create original data regarding the use of stacked growing trays in a CEA and how this could add enough to the yield to offset intensive energy use.

Local Food Trends

I researched market trends to find out if a large-scale CEA is likely to be profitable in the future. This included studies on the popularity of local food and the economic feasibility of a small CEA farm's ability to access economies of scale.

I investigated the sustainability of local food systems, taking into account methods of storage, transport and production. I compared hyper-local and regional systems, taking into account the full supply chain and whether consuming local should shape the future of agriculture.

Chapter III

Results

Review of the two Detroit CEA farms indicated that turning a vacant warehouse into a CEA farm in Detroit is feasible if a person invests in their own business. Since the cost to buy a warehouse is fairly low if you also have the equipment, your product can be ready in a short amount of time. Table 3 shows cost of each farm's building and equipment, crops grown, and distribution. Accessibility to the market will be slightly more difficult than community gardens that have a pre-set area for distribution. A private CEA farm must reach out to find its own places to distribute. The difficulty of this task depends somewhat on ideology, and whether people trust food that is grown indoors, without soil. It is difficult to find data on the reaction of the consumer to produce grown in controlled environments, apart from the positive responses I witnessed when touring Artesian Farms, Green Collar Foods and The Plant (Chicago). Whether the demand for and consumption of this product will be consistent enough to support the industry in Detroit remains to be seen.

Based on information from Artesian Farms and Green Collar Foods, CEA farming in Detroit has definite potential as long as one understands the investment necessary and the difficulties with selling your new version of a classic product (food), and having people be wary of that. Use of renewable energy is necessary if the purpose of the farm is to be more sustainable than business-as-usual agriculture (as per results below on energy use/yield). Both of these farms use stacked growing trays, which is crucial for increasing yield vs. energy use. One thing that could be helpful is Detroit's pride in its urban farming history and being the best example in the country of how this helps to rejuvenate a city. This could lead towards room in the market for innovations that allow for more local produce, as well as probable interest in the city from outside investors.

Table 5. Background information for two case study Detroit CEAs.

CEA	**Location**	**Size**	**Distribution**	**Cost**	**# of Employees**	**Crops**
Artesian Foods	Detroit, MI	7200 sq ft (building size)	4 stores 6 restaurants	$35,000 warehouse/ $110,000 equipment	2	Leafy greens, lettuce, kale, basil
Green Collar Foods	Detroit, MI	216 sq ft (growing space)	Eastern Market –Indoor farmer's market, open weekends	$300,000 suggested investment for 5,000 sq ft	2	Leafy greens

(Source: Artesian Farms owner Jeff Adams and Green Collar Foods Operations Director Darren Riley).

Assessment of Other US CEAs

There are several more CEA farms in the midwest as well as the east coast, and as much information was gathered as possible without an in-person visit. Other notable farms reviewed included Green Spirit Farms in New Buffalo, MI; CEA Paradise in Grand

Rapids, MI; Farmed Here in Chicago, IL; The Plant in Chicago, IL; and Green Sense Farms in Portage, IN. On the east coast there is also Aerofarms in Newark, NJ; Bright Farms in New York, NY; Gotham Greens in Brooklyn, NY, and Little Leaf Farms in Devens, MA. Table 4 shows relevant information gathered from the websites of these farms.

Table 6. Crops, methods and distribution of midwest and northeast CEAs.

CEA	Location	Crops	Growing Method	Distribution (# of stores/restaurants)
Green Spirit Farms	New Buffalo, MI	Lettuce Basil Arugula Spinach Kale	Hydroponic	20
Farmed Here	Chicago, IL	Lettuce Kale Arugula Basil	Aeroponic & Aquaponic	80
Green Sense Farms	Portage, IN	Lettuce Herbs Baby greens	Hydroponic	10
AeroFarms	Newark, NJ	Baby arugula Baby kale Watercress Leafy greens	Aeroponic	5 + on-site market
Bright Farms	New York, NY	Baby spinach Baby arugula Baby kale Romaine lettuce Basil Tomatoes	Various Methods	50
Gotham Greens	Brooklyn, NY	Lettuce Arugula Basil Kale Tomatoes	Hydroponic	300
Little Leaf Farms	Devens, MA	Lettuce Leafy greens	Hydroponic	10

(Source: individual farm websites).

Comparisons of Energy Use and Yield of CEA vs. Traditional Farming

Use of stacked growing trays can make indoor farming more energy efficient. Using Barbosa's numbers on the comparison of energy use and yield for CEA and traditional farming of lettuce, I made an assumption that (when using growing trays) heating and cooling uses would stay the same (74,000 kJ/kg/y) since the room is the same size, while lighting (15,000 kJ/kg/y), and water pumping (640 kJ/kg/y), respectively, would go up by the initial set amount each time a new level of growing tray is added (Table 7). For example, if a growing tray is added and the yield (41kg/m2/y) doubles to 82, the lighting doubles to 30,000 kJ/kg/y, and the water pumping doubles to 1,280 kJ/kg/y, while the heating and cooling stays the same at 74,000 kJ/kg/y. And since heating and cooling makes up much more of the overall energy use (82%), the energy use for the yield starts to look more sustainable with the use of stacked trays (Table 7):

- Total energy use from three levels of hydroponic growing trays = 120,920 kJ/kg/y
- Total yield with three levels of hydroponic growing trays = 123 kg/m2/y

Based on the original numbers of 90,000 kJ/kg/y for a yield of 41 kg/m/y, the yield is three times higher and the energy use is only about 1/3 higher. This shows that stacking growing trays is a potential solution to managing energy use by CEA farms, in addition to taking the advice of Barbosa and his team to experiment with solar energy and logistically placed farms in climates that are most efficient. The study introduces the idea of local climate having an effect even on indoor farms, and should prevent projects from being taken on that may not be successful.

Table 7. Energy breakdown calculations for stacking 2-3 growing trays.

	1 Level Hydroponic	2 Level Hydroponic	3 Level Hydroponic
Heating & Cooling (kJ/kg/y)	74,000	74,000	74,000
Lighting (kJ/kg/y)	15,000	30,000	45,000
Water Pump (kJ/kg/y)	640	1,280	1,920
Yield (kg/m2/y)	41	82	123

Source: Artesian Farms owner Jeff Adams; Green Collar Foods Operations Director Darren Riley

A previously mentioned study by the Macrothink Institute envisioned a CEA farm that was 37 floors and found that it had a yield 516 times higher (3,600 tons fruits and vegetables) than the same land area of a traditional farm, because of stacking and year-round harvests (Banerjee, 2014). If the Barbosa yield of 41 kg/m/y at one level was multiplied by 37 to calculate the yield of using 37 floors of growing trays, the yield would be 1,517 kg/m/y. Using the assumptions in Table 7, the energy use for 37 floors could be calculated as 15,000 (lighting) multiplied by 37; plus 640 (water) multiplied by 37; plus 74,000 (heating and cooling, which stays the same with extra growing trays). This means the energy use for 37 floors would be 652, 680 kJ/kg/y. This is a huge number, but comparing it to the original data from the Barbosa study could be the key to energy-efficient CEA. The CEA hydroponic yield was 11 times higher than traditional, and the energy use 82 times higher (Figure 11). Using the new numbers for 37 floors show that the CEA hydroponic yield is 389 times higher and the energy use is 593 times higher. These are large numbers and difficult to compare. However, if broken down fractionally, 82/11 = 7.45 and 593/389 = 1.5. So with 37 floors, the difference between the yield and the energy use is only 1.5, while the difference with one floor is 7.45.

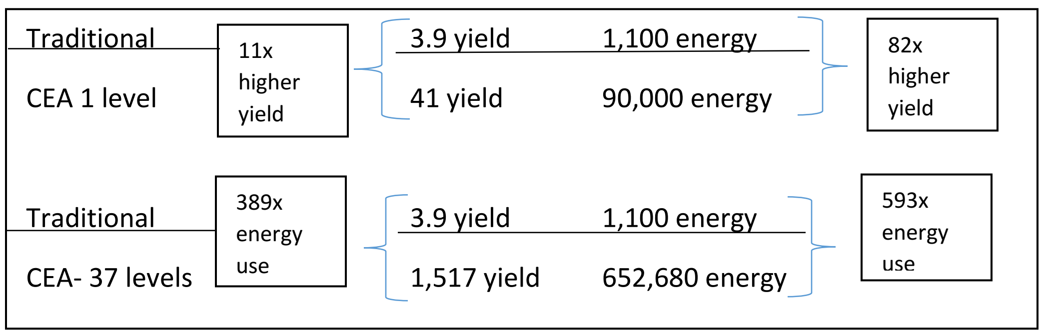

Figure 11. Yield Comparisons of Traditional and CEA with 37 Levels.

This shows that stacking eventually reduces the difference between yield and energy use, making the CEA farm more energy efficient. However, it is of course not always practical to have 37 floors for growing trays. In fact given how many floors it takes to reach something energy efficient, this may not be enough to view CEA as a sustainable option. However, and this is critical, neither the Barbosa or Banerjee studies include any sort of renewable energy. Therefore, it is likely that with a combination of renewable energy, traditional energy, and stacked growing trays, that CEA can be as energy-efficient as traditional farming, with the added benefits of not using large amounts of land and not using chemicals that end up in the environment.

Chapter IV

Discussion

A possible course of action is to implement renewable energy CEA farms in cities in an amount where the city actually produces more of its own food, and transports less in from outside sources. This also means they can rely less on traditional farms with unsustainable production, and consumers can know where their food comes from. The intention of this is not to put small, rural farms out of business; in fact, the overall fresh food plan for a city should take small farmers into account. The shift in production should come from large-scale traditional farms that are the biggest producers of emissions and are degrading natural lands. This may lead to a shift in the way our economy interacts with agriculture. If the consumer wants local and sustainable food above all else, other parts of the industry will adapt. Another important point is that based on current population calculations, an area the size of Brazil will needed to be used for growing food, in addition to the vast areas already used, by 2050 (Despommier). So having a solid industry in place for growing food sustainably in cities could mean preserving natural lands that would otherwise be used for agriculture in the future, as well as avoiding the emissions that would be produced from transporting those foods all over the world.

Of course, if every American farm had a fleet of electric or solar-powered trucks to bring their food to the market, the argument between urban and rural farming would be different. However, the question as to why the technology for electric vehicles has been available for decades (and would solve a major emissions problem), yet electric cars are not mainstream, is not for this particular study to answer.

In the Detroit example, investing in community gardens may be the best way forward, and large-scale CEA would be better used in higher population cities that can invest in it. On the other hand, since Detroit prides itself on local urban produce, stores and restaurants might be more inclined to carry their products. At least that seems to be the experience of Artesian Farms and Green Collar Foods; whether they can grow enough to compete with larger rural farms will be determined by customer demand.

Small scale CEAs face some similar hardships to small traditional farms in terms of having access to distribution possibilities, but do have the advantage of year-round production and indoor facilities that are not affected by weather and pests. If the demand specifically for local food and food of known origin continues urban CEA farms should have the opportunity to expand, as long as they can make good distribution deals to ensure solid business. This should be able to happen if the consumer demand is for local food. It seems likely that this consumer trend will continue because it is many decades in the making; it is a backlash to the highly processed, unhealthy, factory foods that have dominated the market and lead to increases in obesity, diabetes and other lifestyle diseases. It’s a backlash to steroids, hormones and antibiotics being used in animals we consume and extremely inhuman treatment of those animals. Since nearly 80% of shoppers read nutrition facts (Lin, 2016) it stands to reason that they care about what they eat. One of the keys to this continuing behavior change is to make sure local healthy foods are affordable so no one is prohibited from health because of cost. CEA being born out of urban community agriculture puts it in a good position to do this.

Urban CEA has the potential to reduce transport emissions compared to food that is imported, but its actual current environmental footprint is energy intensive. Large-scale CEA should use renewable energy and be carefully planned to use the appropriate type of energy supplements based on local climate, resource access and customer demand. Repurposing a warehouse is beneficial in cities where there are abandoned areas like Detroit, but large-scale CEA should consider new buildings, designed to use some natural sunlight like a greenhouse, in addition to solar panels and other renewable sources, and fuel-based electricity as a last resort. Regardless of whether new or vacant buildings are used, stacking growing trays is highly beneficial to the yield of a CEA farm and to making is energy efficient and a sustainable alternative to traditional farming. CEA farms should also be able to grow a wide variety of crops in order to position themselves to compete in the future.

If transport emissions and agricultural pollution is actually to be reduced, this means large traditional farms downsizing and likely people losing jobs, not to mention the amount of money and political interest tied up in big agriculture in this country makes is nearly impossible to imagine a future where it is downsized. It is not the worker's fault that this industry is environmentally and economically disadvantageous to the future well-being of the planet and its people. Furthermore many small farms represent the livelihood of entire generations as well as carry tremendous cultural history; if their farming practices are sustainable, they shouldn't be in competition with urban agriculture. An overall restructuring of the agricultural system that uses traditional, organic, urban and CEA in appropriate amounts and with attention to renewable energy is the key to a sustainable future, as well as changing distribution patterns so that produce is transported mostly to local and regional areas. These seem like lofty goals, but if there ever was a time to dream big, it’s now.

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